NATO SCIENCE PROGRAMME
Cooperative Science and Technology Sub-Programme
ADVANCED STUDY INSTITUTE

NATO Public Diplomacy Division, Science Programme, Bd. Leopold III, B-1110 Brussels, Belgium
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GENERAL REPORT

This **General Report** should be submitted to the NATO Scientific Affairs Division within 30 days of the meeting. The **Financial Report** form may be sent later, after consolidation of the accounts, but must be with NATO by no later than 120 days from the end of the meeting. Only after acceptance by NATO of the financial report as well as the present report can any final instalment of the grant be paid.

1. Advanced Study Institute

Title: Seasonal-to-Interannual Climate Variability: its Prediction and Impact on Society

Location: Ecoresort Le Sirene' - Gallipoli – Italy

Dates: 23 May – 3 June 2005
Number of working days: 11

2. Co-directors *(Name, address, telephone no., fax and e-mail)*

i) NATO-country Co-director
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Signature:

ii) Partner-country Co-director
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Signature:

3. Principal members of the Organizing Committee

(Name, position, address)

Prof David Anderson	ECMWF, Reading, UK
Mr Omar Baddour	National Meteorological Service, Rabat, Morocco
Dr Mike Harrison	Meteorological Office, Exeter, UK
Dr Simon Mason	IRI, Earth Institute at Columbia University, Palisades, NY, USA
Dr Alberto Troccoli	ECMWF (Italy), Reading, UK

4. Scientific Area, Scientific Codes and percentage of discipline content *(See NATO classification of scientific subjects)*

Scientific Area* (PST/LST/EST/SST)					
N/A	%	N/A	%	N/A	%

* If using this form to report on a pre-1999 ARW, please enter the relevant Priority Area in box.

5. General Comments

Please give here general comments on the meeting - e.g. comments on the application process, the planning and execution of the meeting itself and follow-up. Financial comments should not be given here but may be made in the financial report. A short one-page scientific summary of the meeting, which may be used for public information, should be prepared on a separate sheet, provided at Annex 2.

The organising committee admitted 82 students in all. The basis for the decision was primarily academic qualification, but to some degree the national distribution influenced the decision. 62 participants from 27 countries attended. A good number of participants were from Eligible Partner countries from Mediterranean Dialogue countries. However, several more candidates from these countries were invited but they decided to withdraw (most of them were offered full financial support) and some even withdrew very close to the start of the ASI, thus precluding the possibility to participate to other qualified applicants (it might be worth considering a way to avoid this, e.g. by making candidates feel more committed when a place is offered to them). From an equal opportunity viewpoint, there were 32 female participants, hence more than male participants (30). The percentage females/males was also very similar in terms of applications (there were in excess of 210 applications).

Most of the participants were graduate students or postdoctoral scientists working at universities, research laboratories or at National Meteorological and Hydrological Services. Some of them were more senior scientists. The participants' background was quite diverse, but many of them had a strong mathematical and/or physical preparation, applied to atmospheric, ocean and/or climate fields. Almost all seemed well qualified to follow the material presented in the lectures and in the practical problem sessions. From the level of discussion, it was clear that many of the participants were extremely sharp.

The programme closely followed our original plan. And although the programme was very intense (see booklet with timetable at http://www.ecmwf.int/staff/alberto_troccoli/nato_asi/asi_programme/index.html#BOOKLET – a few activities were even added during the course, e.g. a demonstration of the statistical software R), participants enjoyed it very much. This is according to their feedbacks, their interventions during and at the end of the lectures and their dedication during the practical exercises. The format of the lectures, with 45min for the presentation and 15min for questions – though lecturers took questions even during the lecture - seemed very appropriate. The exercises turned out to be a very useful complement to the lectures. The thought was to choose four exercises - to be solved numerically, mostly with a computer - to give an overview of the relevant issues of each of the four modules. The exercises were not too complex so that most people – 12 groups were formed, which remained fixed for all four problems - could tackle them in the limited time (2-3 hours) they were given. The results of the problems were then presented by a representative of a selected group through a short oral presentation. Aside from this, participants were also given the opportunity to present their work through posters – those who brought one, that is – which they introduced via brief oral presentations. Their posters were shown in an aisle of the lecture room so that they were easily accessible during breaks.

The organisation of the school went very smoothly. Despite being a novel place for NATO activities, the Ecoresort Le Sirene' (the hotel where the school was held) turned out to be an extremely good location, with a lot of amenities, which helped enhancing interaction amongst participants. In addition, the period of the year was well timed – the temperature was just right and the hotel was mostly occupied by us. The planned social activities, such as visits to important centres in the area – mostly offered by the Province of Lecce – clearly further contributed to the cohesion of the participants. It is the unanimous view of the organising committee – and of all the many feedbacks I received from the participants – that the school was a great success. Personally, I was extremely pleased with the outcome and, in spite of the hard work, I would definitely repeat the experience.

6. National distribution of Lecturers (L) and ASI Students (S) - for Advanced Study Institute
National distribution of Key speakers (K) and other Participants (P) - for Advanced Research Workshop

	L/K	S/P		L/K	S/P		L/K	S/P
NATO countries			***Eligible Partner countries***			***Other Partner countries***		
Belgium			Albania					
Canada		2	Armenia			Austria		
Czech Rep.			Azerbaijan			Finland		2
Denmark		1	Belarus			Ireland		
France		2	Bulgaria		1	Sweden		
Germany		1	Croatia		2	Switzerland		1
Greece			Estonia					
Hungary			Georgia		1	**Sub-Total**		3
Iceland			Kazakhstan					
Italy	2	4	Kyrgyz Rep.					
Luxembourg			Latvia			***Other Countries***		
Netherlands		1	Lithuania		1	***(specify)***		
Norway		2	Moldova					
Poland			Romania		3	Australia	1	1
Portugal		1	Russia		3			
Spain		6	Slovak Rep.					
Turkey		2	Slovenia		1			
UK	5	7	Tajikistan					
USA	5	11	the former Yugoslav Rep. of Macedonia[1]		1			
			Turkmenistan					
			Ukraine		1		1	1
			Uzbekistan			**Sub-Total**		
Sub-Total	12	40	**Sub-Total**		14			
			Med. Dialogue countries					
			Algeria					
			Egypt		2			
			Israel					
			Jordan		1			
			Mauritania		1			
			Morocco	2			15	62
			Tunisia			**TOTALS**		
[1]*Turkey recognises the Republic of Macedonia with its constitutional name*			**Sub-Total**	2	4	**GRAND TOTAL**	72	

7. Publication of results of the meeting

Title of Book (provisional): Seasonal Climate Forecast and its Benefits to Society

Editor(s) : (a) Dr Alberto Troccoli
(b) Prof David Anderson
(c) Dr Mike Harrison

Publisher: Springer
Expected Date of Publication: Late 2005/Early 2006
Editor's Comments: It would be good to have an online version of the book (at a lower cost than the printed one). Also, it would be useful if the word "proceeding" was avoided in any advertisement since the book will be structured more like a textbook than a collection of proceeding.

Please ensure that signatures of the Co-Directors appear on page 1 Date: Reading, 1 July 2005

Attachments : Annex 1– List of Director(s), Lecturers/Key Speakers and ASI Students/Other Participants:
Annex 2 - Scientific Abstract

Annex 1
GENERAL REPORT - ASI or ARW
LIST OF DIRECTOR(S) and LECTURERS (for Advanced Study Institute)

Notes : - Please copy this page in order to have enough for your requirements.
- Please group by country in alphabetical order.
- The Directors' own list of participants can be accepted as a substitute for this form provided all the information required below is given.

NAME	FULL OFFICIAL ADDRESS (Institution, Street, Town, Country)
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Dr Mike Coughlan	Bureau of Meteorology, National Climate Centre, PO Box 1289K, Melbourne, Victoria, 3001, Australia
Dr Antonio Navarra	INGV, v. Donato Creti 12, 40128 Bologna, Italy
Mr Abdallah Mokssit	Direction de la Météorologie Nationale, Face Préfecture Hay Hassani, B.P 8106 Casablanca-Oasis, Casablanca, Morocco
Prof David Anderson	ECMWF, Shinfield Park, Reading, RG2 9AX, UK
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Dr Paul Llanso	56 Cedar Summit Rd., Asheville, NC 28803, USA
Dr Simon Mason	IRI, Columbia University, 61 Route 9W, PO Box 1000, Palisades, NY 10964-8000, USA
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Annex 1
GENERAL REPORT - ASI or ARW
LIST OF ASI 'STUDENTS'

Notes : - Please copy this page in order to have enough for your requirements.
- Please group by country in alphabetical order.
- The Directors' own list of participants can be accepted as a substitute for this form provided all the information required below is given.

NAME	FULL OFFICIAL ADDRESS (Institution, Street, Town, Country)
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Annex 2

SCIENTIFIC ABSTRACT

Advanced Study Institute

Title of Meeting: Seasonal-to-Interannual Climate Variability: its Prediction and Impact on Society

Name and affiliation of Co-Directors:
i) Dr Alberto Troccoli ECMWF (Italy), Reading, UK

ii) Mr Omar Baddour National Meteorological Service, Rabat, Morocco

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Scientific Content

The rapidly-developing science of seasonal to interannual climate prediction has advanced to the point that it is now becoming a very important element in some decision-making systems related to the areas of security, such as water resource management, food security, and disaster forecasts and prevention. Given their low costs and reasonable results, statistical models are the most widely used tools to obtain predictions of the climate system on seasonal to interannual timescales, but increasing efforts have been put into the development of more sophisticated models. These latter models are designed to solve the equations of motion of the climate system numerically, and range in complexity through stand-alone atmospheric general circulation models (AGCMs) up to the so-called fully coupled general circulation models (CGCMs). Although these dynamical models are very complex, it is believed that they provide the best long-term strategy for seasonal to interannual climate prediction and, in fact, several large research and/or operational centres have invested substantial resources in this strategy.

It is well accepted that the predictability of the climate system on seasonal to interannual time scales is mostly an initial-value problem. In fact, by initialising reasonably well the ocean state as well as the land conditions, it is possible to predict how critical boundary conditions such as the sea-surface temperature and - to a lesser extent - the soil wetness and the snow cover, will evolve in the following months. It is the simulation of the evolution of these slowly evolving components of the climate system that allows us to predict atmospheric circulation patterns some months ahead. Of particular relevance is, of course, the prediction of ENSO and of the climate conditions in the tropical areas, which might influence regions remote from the tropics through teleconnections.

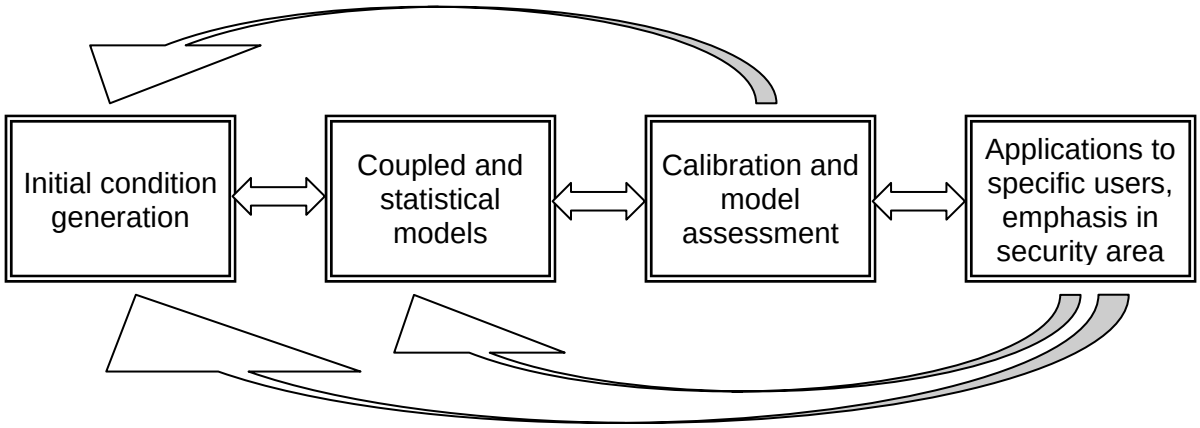
Since it is the slower timescale of variability in the ocean and in the land that affects potential predictability, any attempt to predict seasonal to interannual climate variability in general or ENSO in particular, must involve properly integrated atmospheric, oceanic, land, and possibly cryospheric, models. Furthermore, data assimilation schemes ought to be employed in order to initialise at least the oceanic component, but preferably the other components also. It should be pointed out that if the sole purpose of such systems were to predict indices such as the Niño3 index (essentially the temperature in part of the eastern equatorial Pacific) and a few teleconnected signals, statistical models would offer a much more economical solution. As it turns out, although statistical models have been quite successful in predicting the Niño3 index, they display some serious limitations in certain times of the year (e.g., the “spring barrier” problem). Moreover, their use to forecast climatic conditions in regions remote to the equatorial Pacific Ocean is limited by the scarce availability of robust correlations.

On the other hand, dynamical models allow for a much greater flexibility in the description of climate patterns both globally and regionally. In addition, the possibility to carry out physical-dynamical studies, which are not possible with statistical models, makes them very valuable instruments. However, care has to be taken when analysing AGCM and CGCM results, as these models are so complex that they are not without significant systematic errors. Ways to handle these errors and to convert model outputs to useful products, as for instance by means of appropriate post-processing, have been thoroughly presented at the ASI.

Seasonal to interannual climate forecasting systems can be divided in four components (or modules):

A) Generation of initial conditions for dynamical model forecasts
B) Dynamical models and their coupling
C) Statistical modelling, calibration and model output assessment
D) Application of forecast products to specific users with emphasis on applications related to security

which can be schematically represented as follows:



In particular, it should be noted that given the complexity of each of these components they will inevitably introduce sizeable uncertainties. Therefore, in order to better understand their individual role these four processes were separately addressed. Issues such as comparison of initialisation procedures (component or module A), model errors and ensemble forecasting (module B) and multi-model combination (module C) as a way to deal with model uncertainties were covered in the lectures. Particular emphasis was given to the use of seasonal to interannual climate forecast products to sectors like water security, health warnings, agriculture planning and disaster prevention (module D).

Three main conclusions emerged from the lectures and the various discussions (e.g., during the panel sessions):

1. **Coupled models** appear to be mature enough to be used **in decision making** frameworks. Further model developments as well as increase in model resolution will, however, be beneficial in advancing the science of seasonal forecasting in the long term.
2. Improvements in the underlying science must be matched by improvements in the way we **communicate and integrate** the information into societal structures. Communication with users is therefore a key component of the forecasting system and particular focus should be devoted to this aspect in the near future.
3. The forecasting system should be viewed as a **more integrated system** rather than an *end-to-end* process. The arrows in the above schematics represent exactly these interconnections between the various components of the forecasting systems (end-to-end approach normally only has direct connections from left to right, with no or little feedback between components).

Main lectures given

OVERVIEW (Prof David Anderson)
- The basis for seasonal forecasting
- Pedagogical models of the coupled system
- Coupled model forecasts
- Evaluation of forecasts

MODULE A

Atmospheric data assimilation (Dr Joe Tribbia)
- Historical perspective
- Statistical and variational methods
- Balance Issues
- Current/Future Methods

Ocean data assimilation (Dr Alberto Troccoli)
- Observations and assimilation methods for the ocean
- Impact of assimilation on seasonal to interannual climate predictions

MODULE B

Atmospheric models (Prof Brian Hoskins)
- Basic atmospheric processes
- Atmospheric models and tests of their performance
- Model performance
- Prospects for improving models

Ocean models (Prof Paul Schopf)
- What they can and can not simulate on seasonal to interannual timescales
- Strategies for reducing errors in ocean models
- Limitations and strategies for future development
- Sources of variability in ENSO

Coupled models (Dr Antonio Navarra)
- The Zen and the art of coupled general circulation models (I)
- The Zen and the art of coupled general circulation models (II):
- Sources of Predictability
- A future for seasonal forecasts

MODULE C

Statistical Modelling (Mr Omar Baddour)
- Statistical models as a complement and/or an alternative to dynamical models
- A selection of statistical models and an overview of their uses
- Comparison of forecasts from statistical and dynamical models
- Options for future development of statistical models

Calibration (Dr David Stephenson)
- Introduction to Probability Forecasting
- Bayesian probability forecasts for binary events
- Bayesian calibration and combination
- Verification of Probability Forecasts

Model Output Assessment (Dr Simon Mason)
- One-tiered vs two-tiered forecasting
- Systematic model error correction
- Introduction to downscaling
- Multi-model ensembling

MODULE D

S-I Predictions- An Overview of its Role in Decision Making (Dr Mike Harrison)
- Broad background to the management and social structures

Delivery of forecasts to users
History and current status of applications
Future of services incorporating seasonal to interannual predictions

Regional approach and its evaluation (Mr Abdallah Mokssit)
The genesis of the Long Range Forecast need in North African region and in a country like Morocco
The Scientific Research followed to reach that needs
Development of the tools and forecast products and elaboration of the monthly bulletin in the discussion-validation process
Evaluation of the scores and improvement of the process

Applications of S-I Forecasts to the Health Sector (Dr Paul Llanso)
Identifying the basic relationships between climate and the health outcomes
Digging and cleaning needed datasets
Demonstration of an application
Establishing operational services

Climate-related decision making under uncertainty (Dr Michael Glantz)
Early warning systems (EWS)
El Niño Knowledge for Early Warning and Sustainable Development
Flashpoints as an approach to understanding environmental stresses
Climate Affairs: A holistic approach to climate issues

CONCLUSIONS (Dr Michael Coughlan)
Climate Variability and Change: the overlaps and the differences
Summing up the Programme

PANEL SESSIONS (Dr Jim Williams)
Theme 1: General circulation models (GCMs): prospects and limitations for seasonal to interannual climate forecasting
Theme 2: Are seasonal forecast users benefitting from the extra information coming from GCMs?
Theme 3: How can we improve communication between modellers, forecasters, and application specialists?