Overview of the WWRP/WCRP S2S Prediction Project and Phase II Plans

Andrew W Robertson, IRI
Frederic Vitart, ECMWF
Improve forecast skill and understanding on the sub-seasonal to seasonal timescale with special emphasis on high-impact weather events

Promote the initiative’s uptake by operational centres and exploitation by the applications community

Capitalize on the expertise of the weather and climate research communities to address issues of importance to the Global Framework for Climate Services

The project focuses on the forecast range between 2 weeks and a season.

The S2S Database, hosted by ECMWF and CMA, went online in May 2015. International Coordination Office hosted by KMA.

Co-chairs:
Frédéric Vitart (ECMWF)
Andrew Robertson (IRI)
S2S Predictability

**Weather:**
Initial Value Problem (e.g., baroclinic waves)

**S2S:**
Mixed Initial Value (e.g. MJO) and Boundary Value Problem (e.g. Soil moisture, snow cover/snow pack, sea ice, SST)

**Climate:**
Boundary Value Problem (e.g. ENSO SST anomalies, atmos composition)

**TIME AVERAGING**
Predictability of the Second Kind (Lorenz, 1975)
### Sub-seasonal to Seasonal (S2S) Prediction Project – Phase 1

**Sub-Projects:**
- Teleconnections
- Madden-Julian Oscillation
- Monsoons
- Africa
- Extremes

#### Verification

**Research Issues**
- Predictability
- Teleconnections
- O-A Coupling
- Scale interactions
- Physical processes

**Modelling Issues**
- Initialisation
- Ensemble generation
- Resolution
- O-A Coupling
- Systematic errors
- Multi-model combination

**Needs & Applications**
- Liaison with SERA (Working Group on Societal and Economic Research Applications)

#### S2S Database

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### Subseasonal Ensemble Prediction Systems from 11 Forecasting Centres

**Data assimilation**

**Coupled climate model**
- Atmospheric Model
- Land Surface Model
- Ocean Model

Forecast skill depends on ability to depict initial state.

Based on equations of physics i.e. a computer simulation of the real world (e.g. has clouds, solar radiation...)

Representing uncertainty and chaos

#### Models

<table>
<thead>
<tr>
<th>Models</th>
<th>Ocean coupling</th>
<th>Active Sea Ice</th>
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<tr>
<td>ECMWF</td>
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<tr>
<td>HMCR</td>
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</table>
The S2S Database

Contributing Centres to S2S database

- Data provider (11)
- Archiving centre (3)

- ECMWF
- NCEP
- ECCC
- HMCR
- JMA
- KMA
- CMA
- ECMWF
- Météo France
- UKMO
- ECWMF S2S Server
- 61 articles using S2S DB

S2S Database Models

<table>
<thead>
<tr>
<th>Status on 5th January 2016</th>
<th>Time range</th>
<th>Resolution</th>
<th>Error Size</th>
<th>Frequency</th>
<th>Re-forecasts</th>
<th>Rts length</th>
<th>Rts Frequency</th>
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<tbody>
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<td>2%</td>
<td>weekly</td>
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</tbody>
</table>

Forecasts available 3 weeks
Conversion: 1°x1°

61 articles using S2S DB

ECMWF S2S Server

Over 1000 active users of ECMWF archive
With ~500TB retrieved since 2015.

CMA S2S Data Server

Number of Visits (ten thousands)

Registered user distribution

Data download (Tb)

- ECMWF, CMA, BOM, UKMO, NCEP
- download top five centers
- t, u,v, mx216, gh

S2S Database in IRI Data Library

- Over 2/3 of the S2S database is archived at IRI, including NAO indices
- Updated daily
- Allows server-side and "lazy" computation to analyze the data according to user requests (e.g., weekly averaged anomalies of ensemble means, EOFs, ...)
- Good for low-bandwidth situations
- OpenDAP
- Includes RMM indices
Sub-seasonal Forecast Skill

RPSS of Weekly averages for Northern Extratropics Landpoints, June 2017 – November 2018, vs ERA-Interim

F. Vitart

• some multi-model skill up to 3 weeks ahead
How do Subseasonal and Seasonal forecast skills compare?

Skill is expressed here in Ranked Probability Skill Score which is a multi-category generalization of the Brier Skill Score.

Seasonal Skill

Precipitation Forecasts issued in January

Subseasonal Skill

Subseasonal forecasts are skillful over broader areas than seasonal ones, but skill-maxima are lower.
MJO Prediction

Forecast Lead Time When MJO Index Skill Reaches 0.6

Vitart (2017)

- Big recent improvements in MJO prediction skill
- MJO Teleconnections still show serious biases
Stratospheric Polar Vortex Events

Prediction skill of the 1000 hPa Northern Annular Mode for week 3 in the S2S models

- For most models, skill is higher following weak vortex conditions.
- Similar results are found following strong vortex conditions.

SPARC-SNAP
Calibrated S2S Forecast Product Development

On Feb 13–15 2018, Tropical cyclone Basyang/Sanba hit the Philippines (150,000 affected & 50,000 displaced). Could it be predicted 3–4 weeks ahead?

• Probabilistic multi-model calibrated forecasts show skill
• MJO often plays a role analogous to ENSO in seasonal forecasting

N. Vigaud, IRI
S2S Phase II: 2019–2023

Science

New research foci on improving S2S forecasts and understanding

Research-Operations Applications Dev.

New activities to demonstrate S2S forecast applications value and improve operational infrastructure

Data Infrastructure

Enhance S2S Database
Ocean variables, more surface variables 4xdaily, additional models (eg IMD)
Phase II Science Subprojects

**Land-atmosphere coupling & initialization**
MIPS: LS4P, LFMIP-OBS, GLACE-ESM SnowGLACE.
GEWEX-GASS WGSIP

**Ocean**
Coordinated case studies of ocean extreme events & air-sea interaction. Sea ice prediction assessment.
CLIVAR, CliC

**Aerosols**
S2S/WGNE coord expt with/without interactive aerosols.
4-6 modeling centers
WGNE, GAW

**MJO Teleconnections**
Systematic errors relationships w/ extremes
WGSIP, WWRP

**Ensembles**
Stochastic physics sensitivity expt.
WGNE, PDEF DAOS

**Impact of the ocean obs system**
On S2S forecasts: data denial expts (eg XBT, ARGO T/S profiles)
ECMWF, JMA

**Stratosphere**
Nudging expts to better understand impact of SSWs. Also impact of QBO on the MJO.
SPARC
Phase II Focus on R-O & Applications

Research-Operations
- Develop criteria for GPCs.
- Work with WMO Lead Centre for long-range forecasts on real-time MME product.
- Recommend verification scores, MME methods, calibration, product development research.

WMO, JWGFV

Real-Time Forecast Pilot Expt.
Real-time access for applications demonstrations. 2-years, 18 projects under dev:
What? S2S forecasts for agriculture, water resources, energy, health, DRM (Floods, drought, TCs) Sea Ice,
Where? Africa, SE Asia, Amazonia, Western US, Europe, S America

WWRP SERA

Toward Climate Services

S2S Applications Network

International Research Institute for Climate and Society
EARTH INSTITUTE | COLUMBIA UNIVERSITY
IRI Subseasonal Forecast Maprooms

Lagged S2S, every ~month

S2S Lagged Forecasts

Precipitation Probability Forecast
Calibrated Subseasonal Tercile categories precipitation experimental forecasts issued 1-2 months behind real time.

Precipitation Hindcast Skill
Subseasonal skill score based on the historical performance of each model and their multimodel ensemble.

Real Time SubX, every Friday

http://iridl.ldeo.columbia.edu
S2S and SubX databases in IRI Data Library

ECMWF S2S

ECMWF S2S: WWRP/WCRP Sub-seasonal to Seasonal Prediction Project.

Documents
- overview: an outline showing sub-datasets of this dataset
- BAMS paper
- ECMWF Model Table
- S2S Project
- ECMWF S2S Wiki Page
- S2S Description Table at ECMWF S2S Wiki Page
- IRIDL S2S data examples

Datasets and Variables
- BOM BoM POAMA Ensemble.
- CMA Beijing Climate Center (BCC) Climate Prediction System version 1 for S2S.
- CNRM CNRM Ensemble Prediction System.
- ECCC ECCC Ensemble Prediction System.
- ECMWF ECMWF Ensemble.
- EI Era Interim Reanalysis.
- HMCRC HMCRC Ensemble.
- ISAC ISAC-CNR Ensemble.
- JMA JMA Ensemble System.
- KMA KMA Seasonal Prediction System.
- NCEP NCEP CFSv2 Ensemble.
- UKMO UKMO Ensemble Prediction System.

Models SubX

Models SubX: Subseasonal Experiment (SubX).

Documents
- overview: an outline showing sub-datasets of this dataset
- CTB NOAA Climate Test Bed Website
- DataCite DOI Metadata DOI:10.7916/D8PG249H
- SubX Data Information Model/Data Information from SubX Project Website
- SubX Project SubX Project Website

Datasets and Variables
- CESM Models SubX CESM[30LCSM1 46LCESM1]
- ECCC Models SubX ECCC[EGM]
- EMC Models SubX EMC[GEFS]
- ESRL Models SubX ESRL[EMIRIP1]
- GMAO Models SubX GMAO[EGOS_V2p1]
- NCEP Models SubX NCEP[CFSv2]
- NRL Models SubX NRL[NEMS]
- RSMAS Models SubX RSMAS[CCSM4]

http://iridl.ldeo.columbia.edu
Summary

- S2S is still an emerging area of research, improving forecast capabilities and product development – bringing together weather and climate communities toward more “seamless” prediction across scales, as well as researchers/forecasters/users.

- Creation of multi-model NMME, S2S and SubX databases has accelerated development.

- Second 5-year phase of WWRP/WCRP S2S Project research foci on ocean and sea ice, land surface, stratosphere, atmospheric composition, and ensemble generation – started Jan 2019.

- New S2S R2O focus on forecast and verification products development. An S2S “real-time pilot” will enable real-time demonstrations across a spectrum of applications & GFCS sectors.

- SubX project is real-time and demonstrates the value of multi-model combination to enhance skill.