



# Sub-seasonal to Seasonal Prediction Project (S2S)

*Frederic Vitart, ECMWF*

*Andrew W. Robertson, IRI, Columbia University*

*1 November 2021*

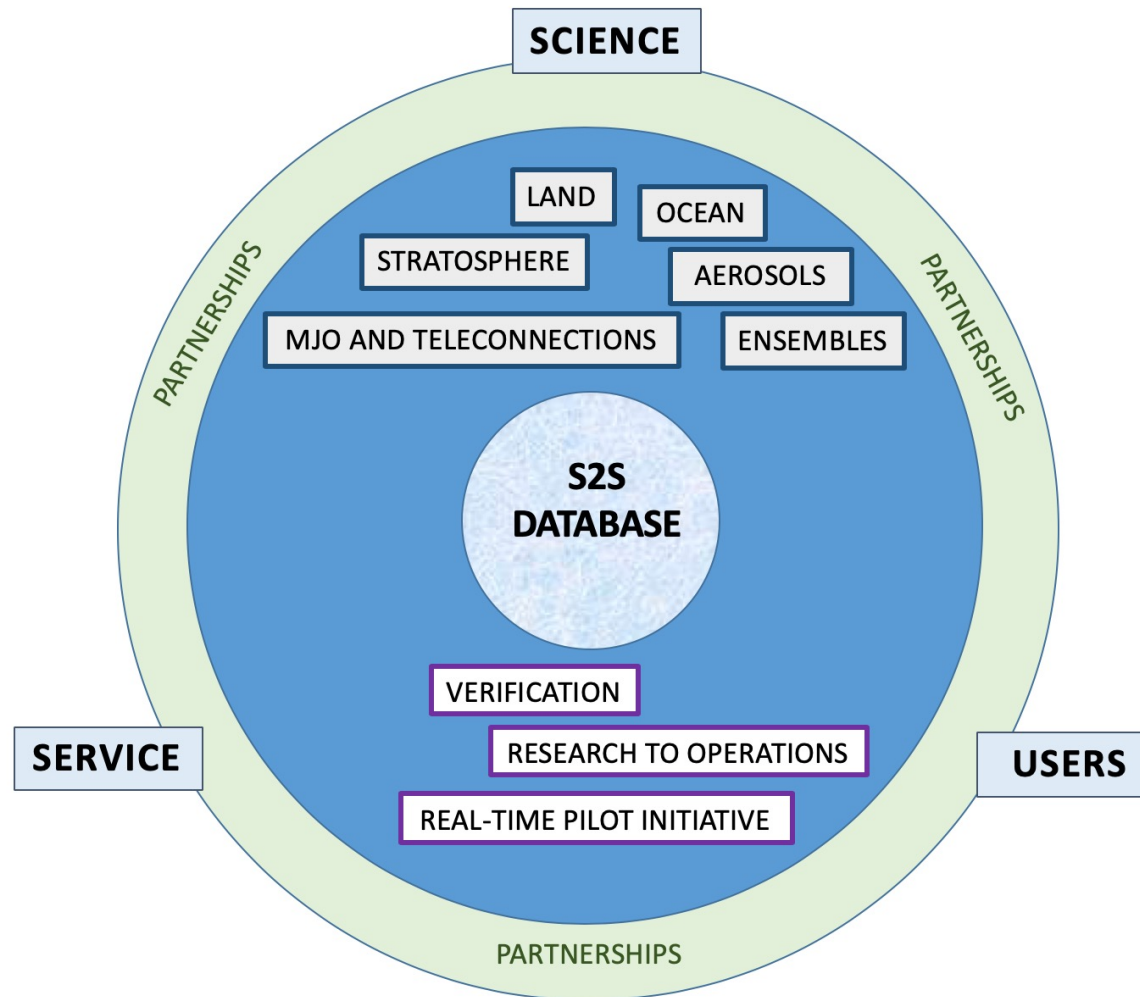


WMO OMM



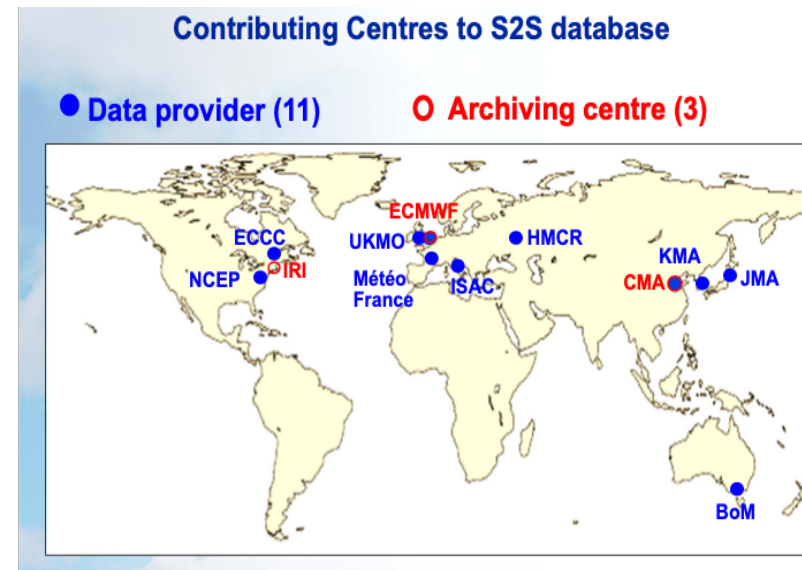
# The WWRP/WCRP S2S Project

- *The S2S project started 2013 and is now in its second phase (2019-2023)*
- *WWRP: S2S is one of the 3 core projects*
- *WCRP: S2S is under ESMO*
- *International Coordination Office hosted by APCC.*
- *Contribution to S2S trust fund from Australia, Canada, UK and Germany.*



# The WWRP/WCRP S2S Database

- Daily 3-week behind real-time forecasts since January 2015 + re-forecasts
- 11 models currently available
- Same grid (1.5 degree) / GRIB2 format
- About 80 variables available, including 3D variables on 10 pressure levels
- Hosted at ECMWF, CMA and IRI
- 10 ocean variables have been recently added
- 1 new model added (Chinese Academy of Science) – Work is ongoing to add NASA-GMAO and IITM
- > 250 publications



# The S2S Real Time Pilot Initiative

- Started November 2019 & will continue until end October 2022 (*includes 1-year extension recently approved*)
- Goals:
  - Identify what is needed to make S2S forecasts usable & how this varies by sector/organisation/experience
  - Understand how projects engage with users & how this relates to pull-through/demand
  - Develop understanding of the S2S forecast value chain & the needs for end-to-end user applications
  - Development of best practice guidelines and/or recommendations to enhance pull-through & sustainability

- Approach
  - 16 co-development projects
  - 3 sets of questionnaires: April/May 2020, Winter 2020/2021, Autumn 2021

- Sectors:**
- Water
  - Energy
  - Health
  - Agriculture/food security
  - Disaster risk reduction

- Countries/regions:**
- Senegal
  - Ethiopia
  - Bangladesh
  - Guatemala
  - Columbia
  - Ghana
  - Kenya
  - Nigeria
  - Singapore
  - USA
  - Europe
  - Asia & Pacific
  - Global



# S2S AI/ML Challenge

- The WMO Research Board has identified Artificial Intelligence (AI) as a key research topic in weather and climate science for the upcoming years
- A competition has been organized to encourage the use of AI tools to extract valuable information from the S2S database.
  - **Can purely empirical forecasts beat S2S systems?**
  - **Can AI/ML methods improve S2S system forecasts by better calibration/multi-model ensemble methods?**
- Hosted by Swiss Data Science Center at ETH Zürich, with ECMWF support through the new European Weather Cloud for data access and some CPU time
- A contractor has been hired by WMO
- Timeline: July 2021 – Feb 2022
- **All codes and forecasts will be made open source** after the end of the competition to foster community learning on AI/ML methods for S2S
- Small monetary prizes from WMO

# Phase II Science Subprojects

## Land-atmosphere coupling & initialization

MIPS: LS4P, LFMIP-OBS,  
GLACE-ESM SnowGLACE.

GEWEX-GLASS

WGSIP

**Ocean** coordinated case studies of ocean extreme events & air-sea interaction. Sea ice prediction assessment.

CLIVAR, CliC

## Aerosols

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

WGNE, GAW

## MJO

### Teleconnections

Systematic errors  
Relationships  
w/extremes

WGSIP, MJO-TF

## Ensembles

Stochastic physics  
sensitivity expt.

PDEF

**Stratosphere** Nudging expts to better understand impact of SSWs. Also impact of QBO on the MJO.

SPARC



# Science sub-project activities

## Coordinated experiments:

- Evaluating the Impact of Aerosols on NWP and Subseasonal Prediction (WGNE-S2S-GAW Coordinated experiment)
- Coordinated experiment to better understand stratosphere-troposphere interaction in NWP and climate models (Collaboration with SPARC/SNAP)
- Ocean observing system experiments to better understand the impact of ocean observations on sub-seasonal forecasts

## Community papers:

- Sudden stratospheric warming prediction and impact on the troposphere (2 papers, Domeisen et al, 2020)
- Diagnosing MJO teleconnections in S2S models (Stan et al. 2021, submitted to BAMS).
- S2S ocean forecasting (DeMott et al., submitted to EOS)

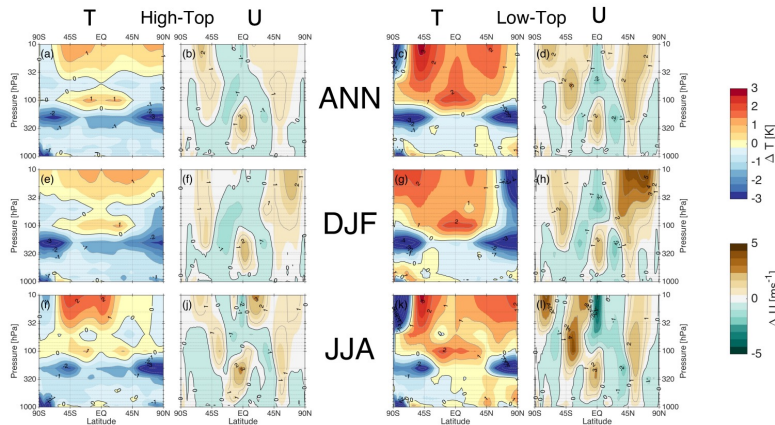


# Stratosphere sub-project

## (Led by D. Domeisen - Link with SPARC/SNAP)

### 1. Stratosphere-troposphere biases in S2S models

- Activity led by Zachary Lawrence (NOAA/CIRES) to quantify stratospheric biases in the S2S models and their relationship to skill.
- Current status: two papers in prep; analysis for paper #1 completed, paper draft underway.



- S2S zonal-mean biases (day 28) relative to ERA-interim.
- Common features: extratropical UTLS cold bias, tropical stratospheric wind easterly bias, overall too warm in stratosphere (radiative problem?), NH polar vortex too strong and cold
- Biases generally more severe in low top models

### 2. Stratospheric nudging and predictable surface impacts (SNAPSI)

- Activity led by Peter Hitchcock (NOAA/CIRES) for investigating the role of the polar stratosphere in sub-seasonal forecasts using nudging experiments. The basic experimental design proposes to focus on the evolution of several specific events as case studies. Experimental protocol to be submitted to GMD – 10 modelling centres are participating



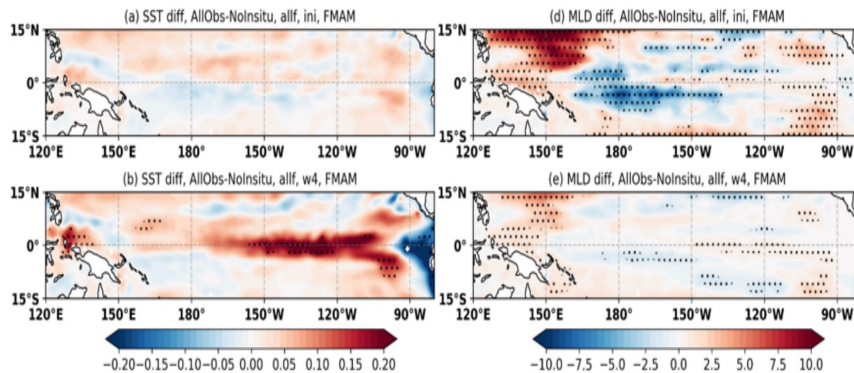
# Ocean sub-project (Led by C. DeMott)

## 1. Tropical Pacific OSEs

Magdalena Balmaseda  
Frederic Vitart  
Beena Balan Sarojini  
(ECMWF)

Aneesh Subramanian  
Kris Karnauskas  
Ho-Hsuan Wei  
(CU Boulder)

Charlotte DeMott  
(CSU)

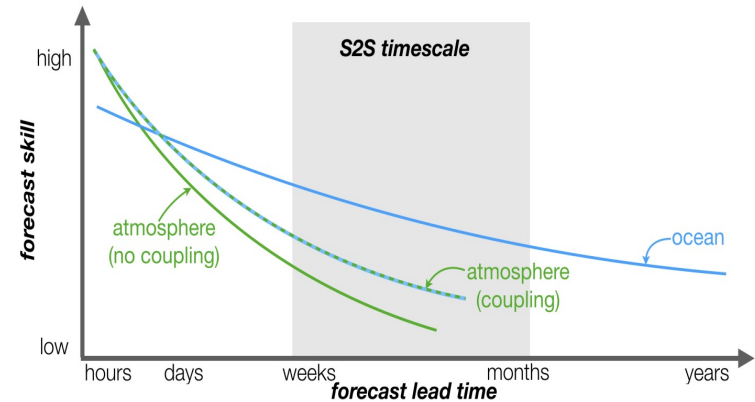


take home message:

AllObs vs Nolnsitu improves SST forecast skill but not MLD forecast skill

## 2. Promoting S2S ocean output

- Eos article: *The Benefits of Ocean Weather Forecasting*
  - DeMott, Muñoz, Roberts, Spillman, Vitart
  - a “climate services” approach to motivating analysis of S2S output



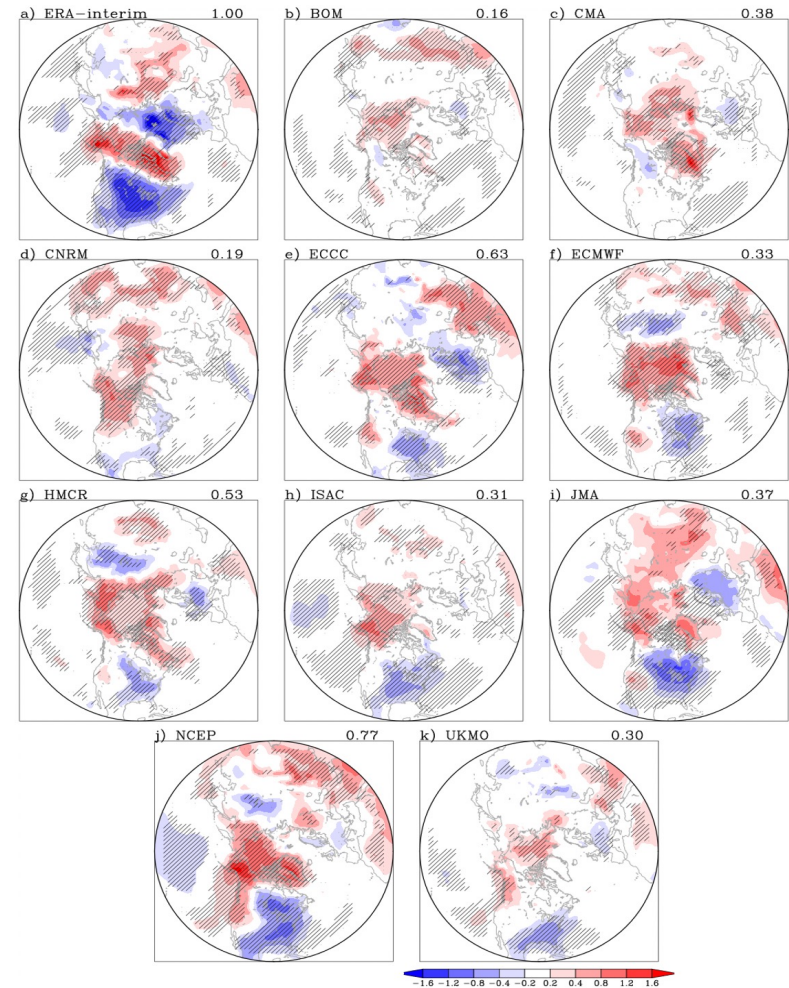
sector	shipping	storm avoidance	route planning	equipment procurement		
	fisheries	storm avoidance	labor needs	equipment purchases		
	coastal water management	issue flood warnings	prestige emergency supplies	lease sites		
				infrastructure planning		
		hours	days	weeks	months	years
		decision lead time				

# MJO-teleconnection sub-project

## Led by C. Stan

Community paper on MJO teleconnection diagnostics applied to S2S models (Stan et al, submitted to BAMS)

Most of the diagnostics are process-based.



Composite of 2mtm anomalies following an MJO in phase 6-7

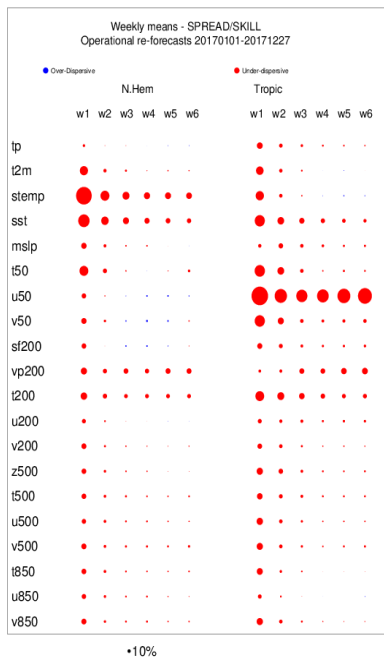
# Ensemble sub-project (Led by Y. Takaya)

## Benchmarking a spread-error relationship

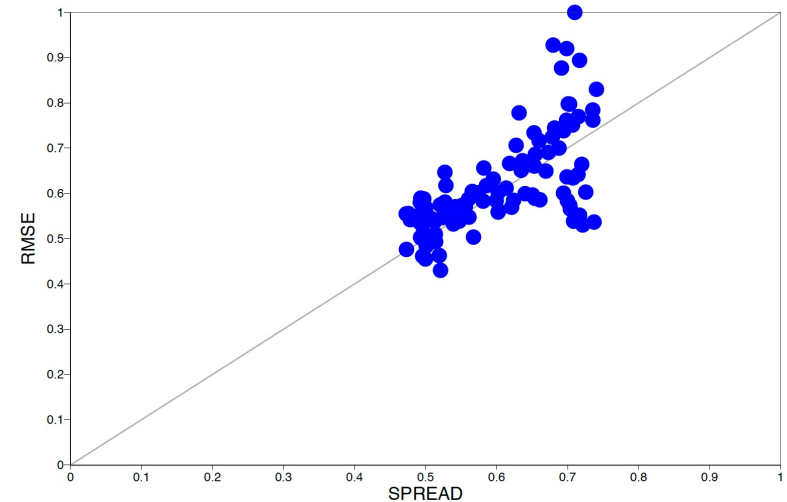
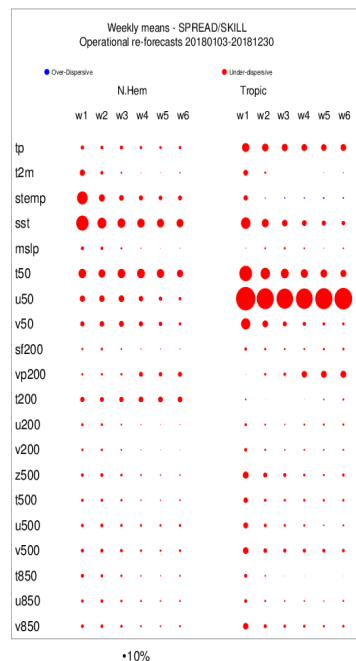
Can we forecast the forecast skill from the S2S ensemble prediction?

→ Yes, to some extent (in ECMWF model).

Reforecasts produced in 2018  
Verification against ERA interim



Reforecasts produced in 2018  
Verification against ERA5



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S2S ensemble prediction?

→ Yes, to some extent (in ECMWF model).

# Connections with WGNE

- **WGNE–S2S GAW aerosol experiments (ongoing)**
- **Coupled initialization (new initiative by Tim Graham)**

Possible topics of common interest:

- Errors in the representation of MJO Teleconnections
- Ocean weather prediction
- Impact of atmosphere/ocean resolution on S2S prediction