ESM-SnowMIP Update

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INARCH 2021 Online Workshop, 18-20 October

Climate and Cryosphere

Understanding the changing cryosphere and its climate connections

GEWEX INARCH

THE UNIVERSITY of EDINBURGH

ESM-SnowMIP

The Earth System Model – Snow Model Intercomparison Project (ESM-SnowMIP):

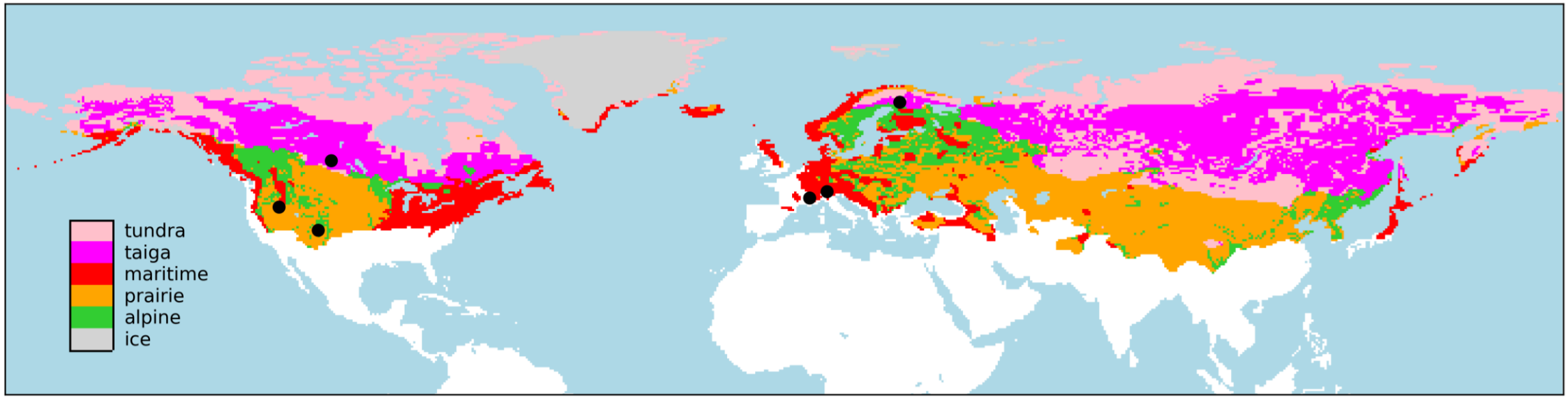
- is an activity of the WCRP Climate and Cryosphere (CliC) project
- aims to improve understanding of snow as a component of the global climate system through:
  - global coupled land-atmosphere-ocean simulations in CMIP6
  - global land-only simulations in LS3MIP
  - land-only simulations at well-instrumented reference sites
    (snow hydrology and snow physics models can also contribute)

Model intercomparison

Intercomparison:

- is an important part of the IPCC process (although CMIP is actually coordinated by WCRP)
- is not a word in the dictionary (Concise OED goes straight from “intercommunion” to “interconnect”)
- makes convenient project acronyms (AMIP, CMIP, LS3MIP, LUMIP, PMIP, SnowMIP, ...)
- has “provided limited insight into the causes of differences in model behaviour”
  Martyn Clark et al. (2015), *Water Resources Research*, **51**
- is “a tedious and thankless task of dubious scientific merit”
  John Pomeroy, pers. comm.
- sets models up to fail in a meaningless task for which they were never intended?

Initial ESM-SnowMIP reference sites



Mid-latitude alpine and taiga:

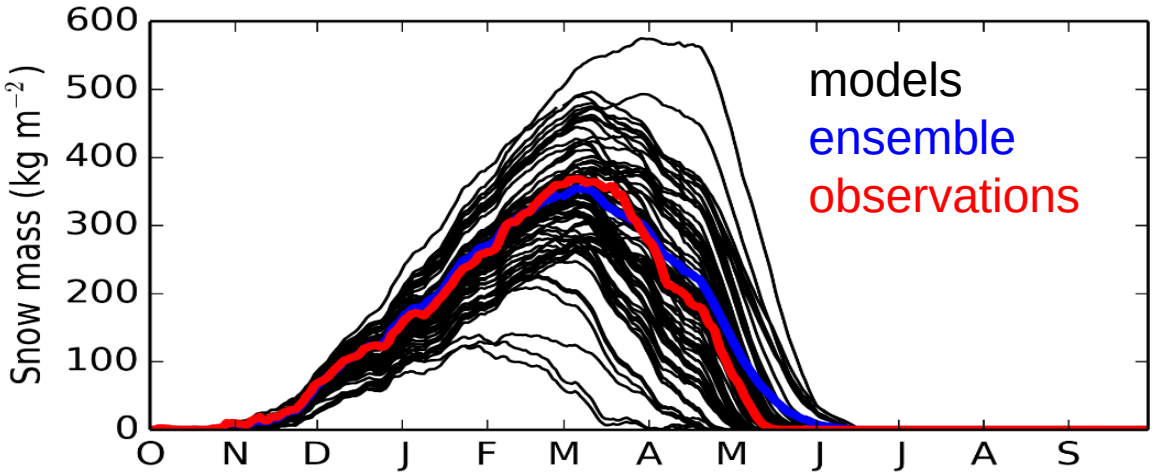
- BERMS
- Sodankylä
- Col de Porte
- Reynolds Creek
- Senator Beck
- Weissfluhjoch

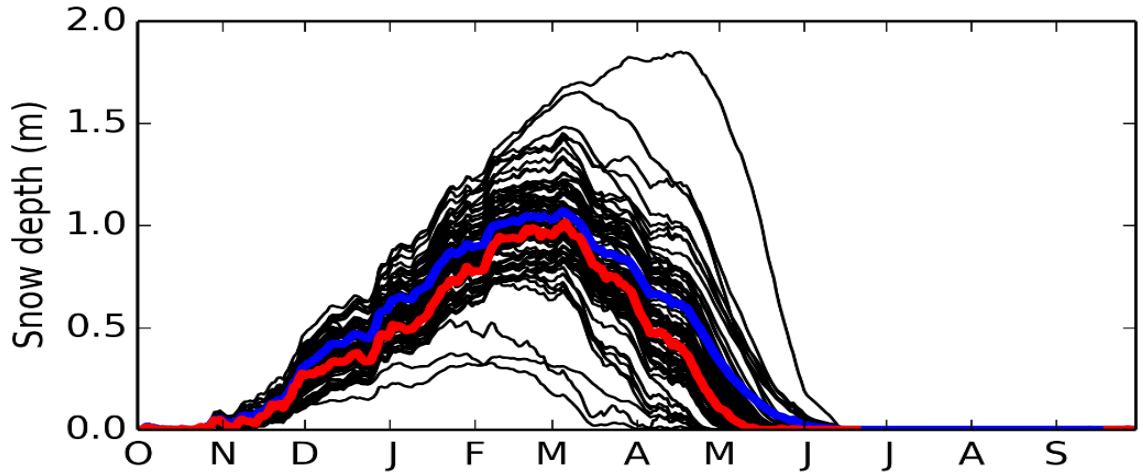
} INARCH research basins

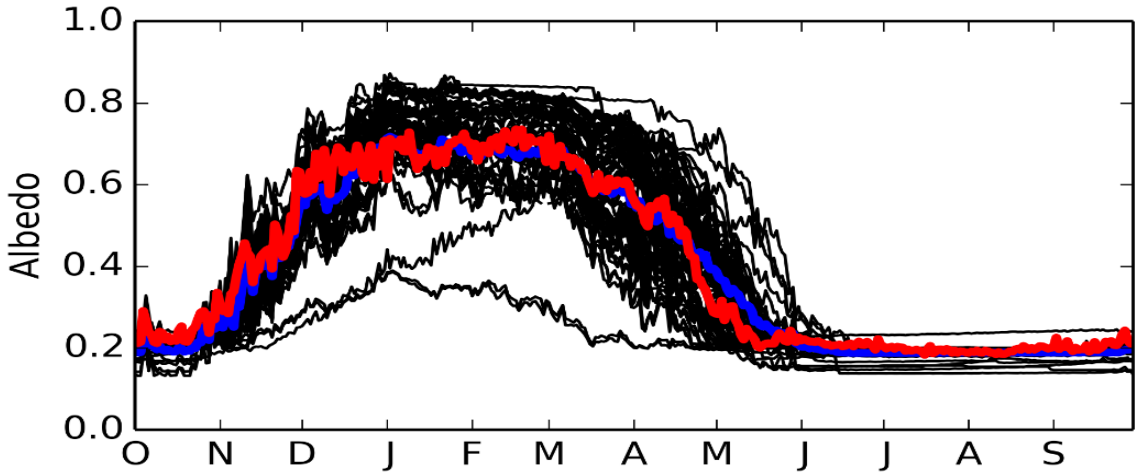
Unsurprising results

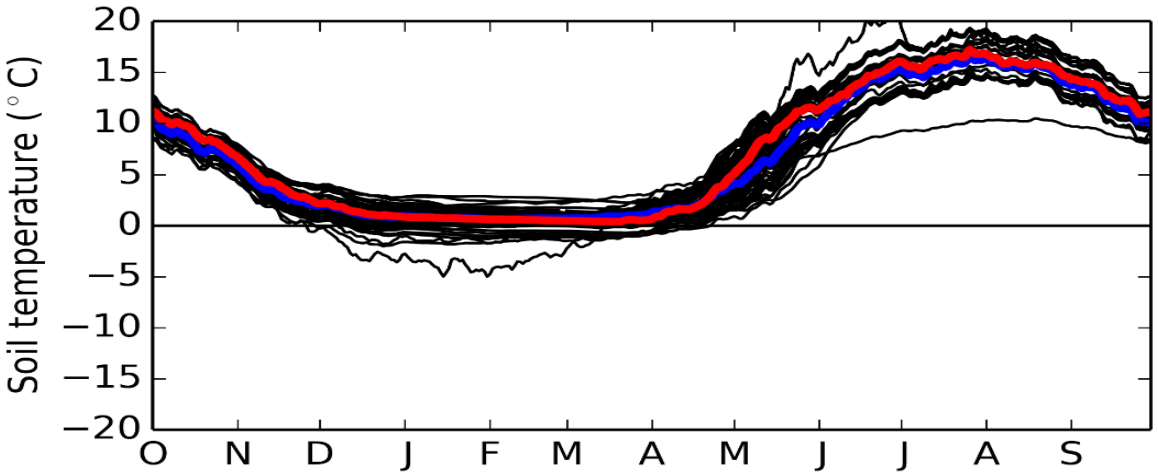
- models differ widely
- there is no “best” model
- there are some “good” and “bad” models

- model ensemble encompasses observations
- ensemble mean is better than most individual models



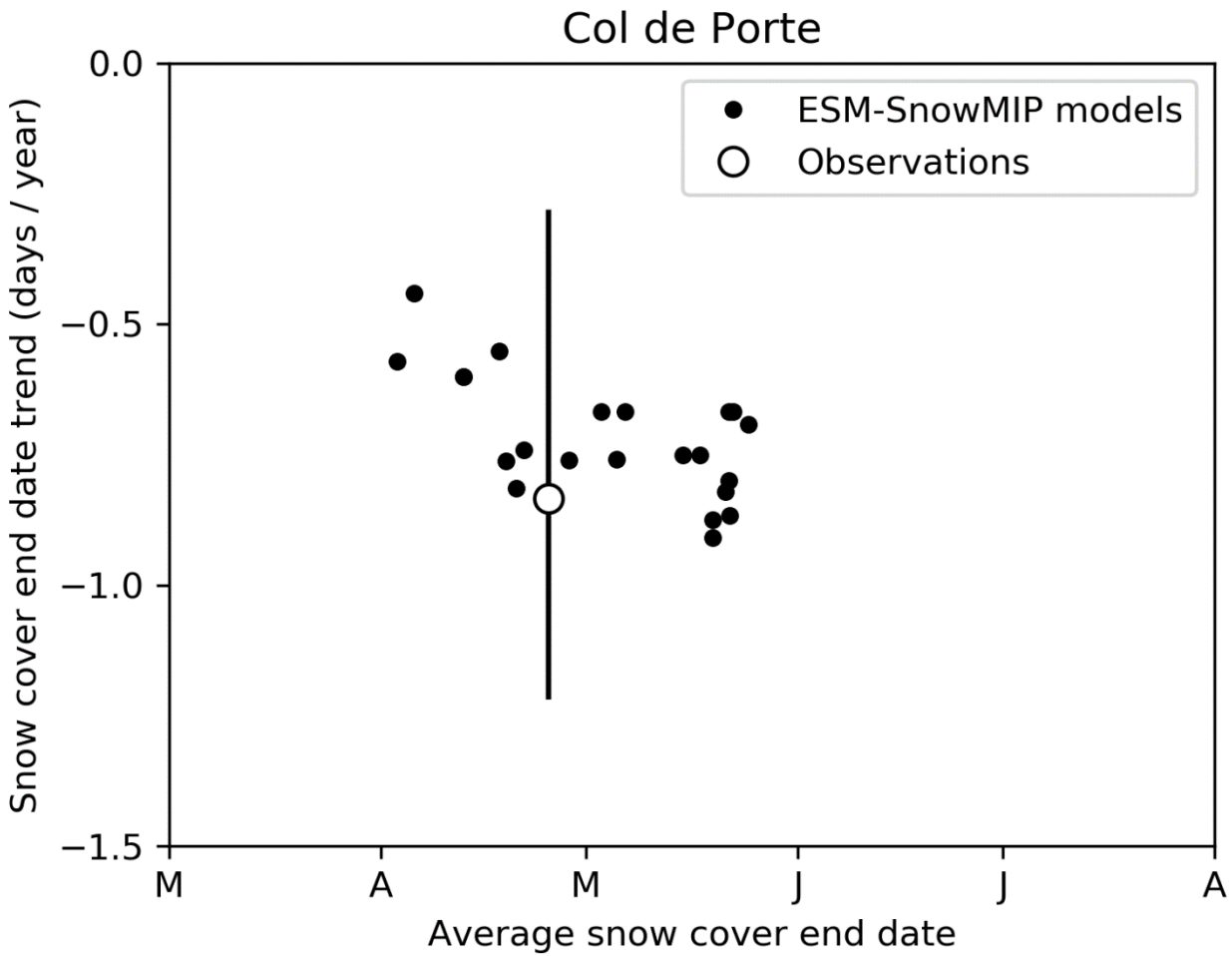


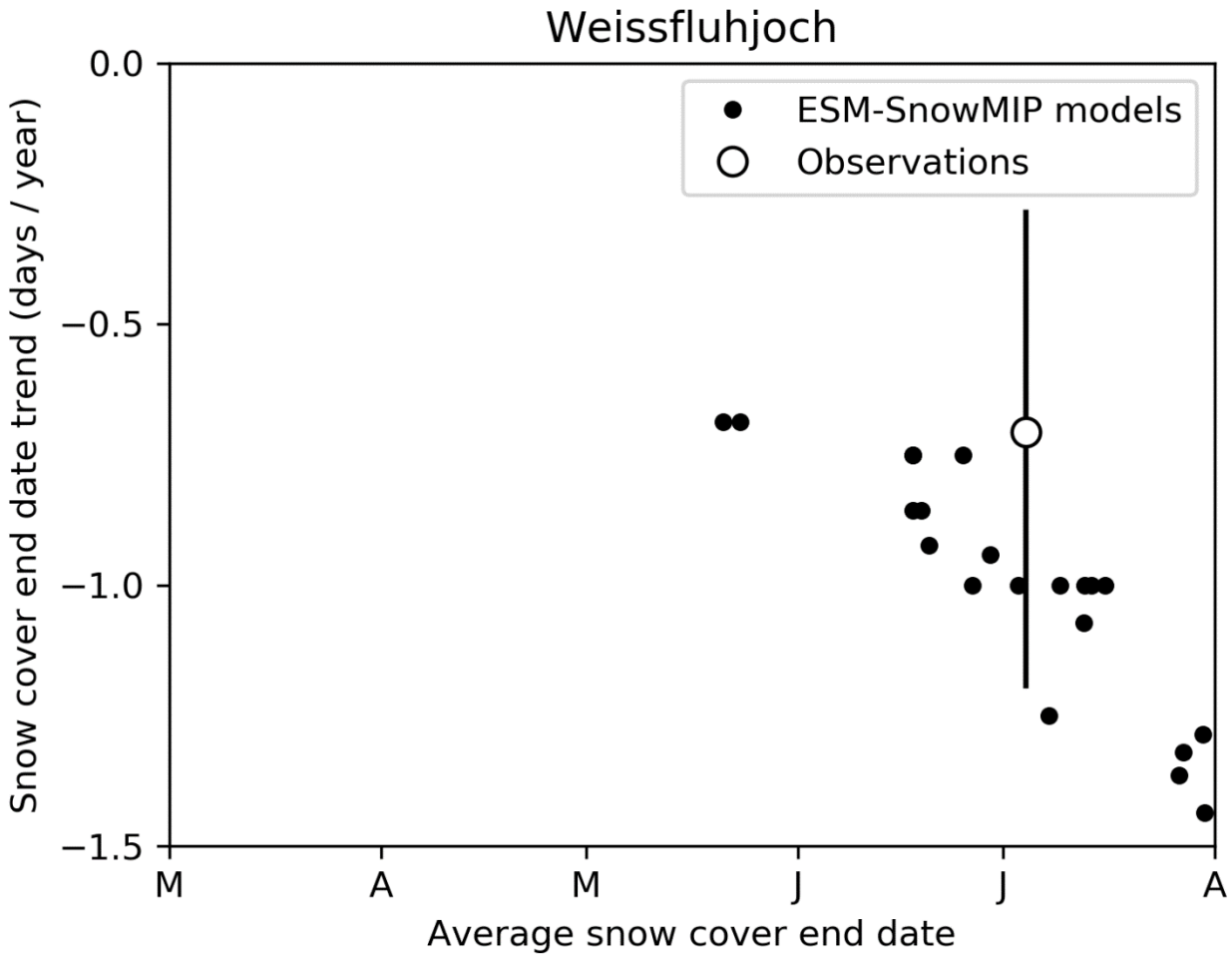




Snow model climate sensitivity

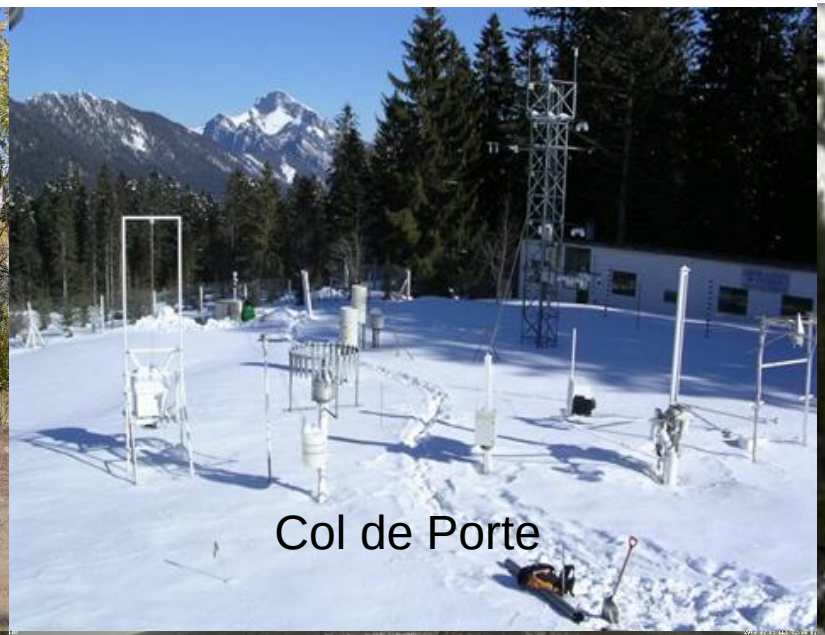
Snow models that melt snow earlier in the current climate are less sensitive to climate trends ("slower snowmelt in a warmer world" and emergent constraint on snow-albedo feedback)





“Holes in the forest”


Reynolds Mountain East

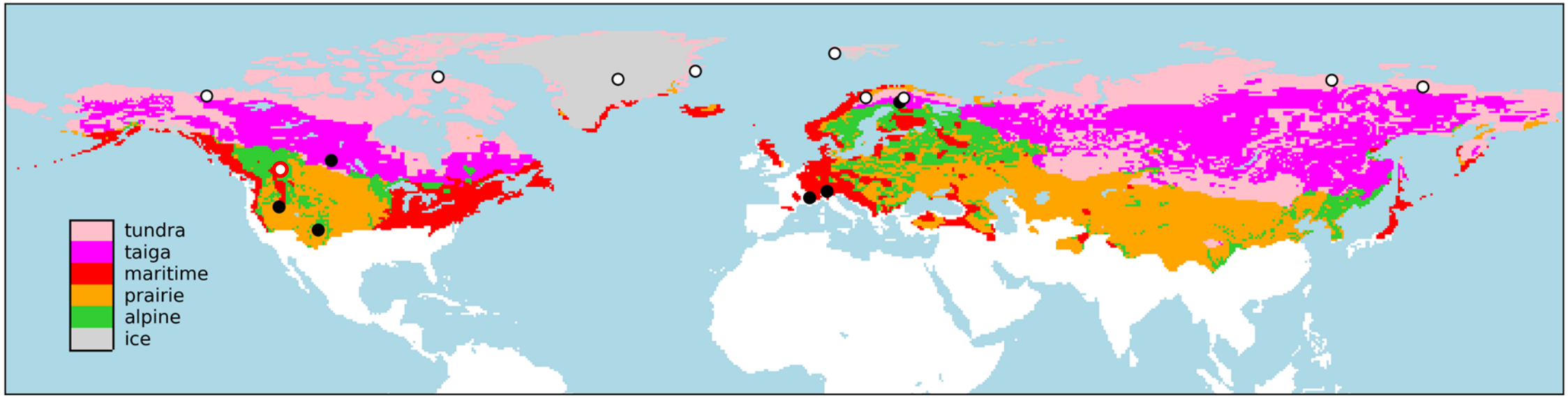

Col de Porte


Swamp Angel


Marmot Creek Upper Clearing


Sodankylä IOA

Additional ESM-SnowMIP reference sites

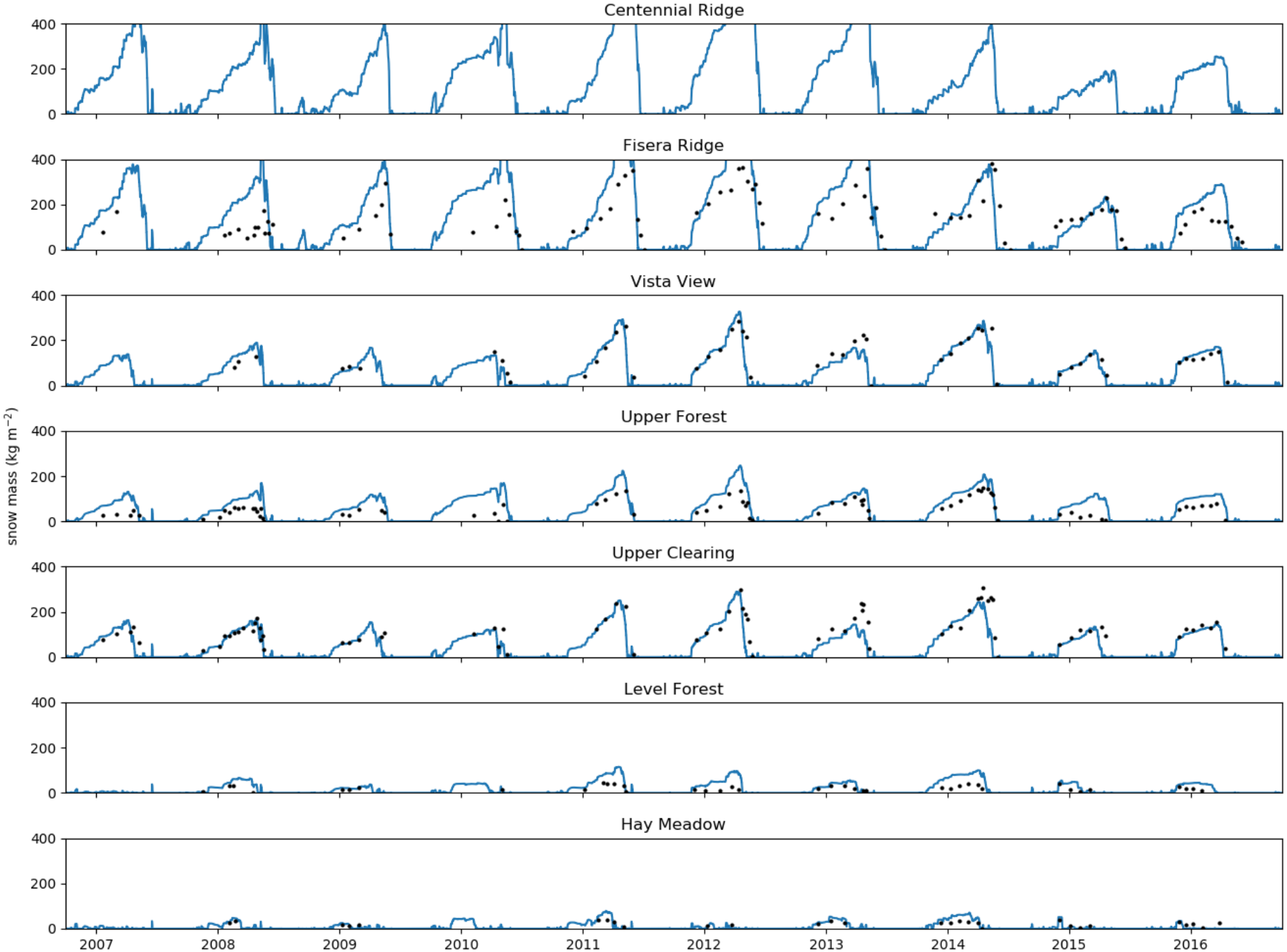


High-latitude tundra and ice:

- Abisko
- Bayelva
- Bylot Island
- Greenland Summit
- Kytalk
- Saariselkä
- Samoylov Island
- Trail Valley Creek
- Zackenberg

Elevation transect:

- Marmot Creek
  - Hay Meadow (1436 m)
  - Level Forest (1492 m)
  - Upper Clearing (1845 m)
  - Vista View (1956 m)
  - Fisera Ridge (2325 m)
  - Centennial Ridge (2470 m)


Centennial Ridge
Fisera Ridge
Vista View
Upper Forest
Upper Clearing
Level Forest
Hay Meadow
snow mass (kg m^{-2})
0
200
400
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

ESM-SnowMIP and INARCH

ESM-SnowMIP reference site simulations:

- test ability of models to reproduce point observations when driven with in situ meteorology
- an intercomparison of models intended for non-snowdrift permitting scales with data from the Marmot Creek elevation transect seems futile

Earth System Model land surface needs to:

- provide energy and mass flux boundary conditions for the atmosphere
- get the right large-scale average snow mass and snow cover fraction when driven with large-scale meteorology

Community question:

- what would be a meaningful and useful experiment with an ensemble of large-scale models for mountain snow?

AlpSnow

INARCH 2021 Online Workshop

18-20 October 2021

Richard Essery

AlpSnow objectives

AlpSnow is

- a science activity within ESA's Alpine Regional initiative,
- addressing objectives set by the Alps from Space Workshop, June 2018,
  - advancement in measurements of seasonal snow cover extent and its physical properties
  - integration of EO-based snow cover information in snow process and hydrological models
  - support for regional operational hydrology and water management using EO-based products
  - contribute to international hydrology and environmental research initiatives in mountain areas
- representing an ESA contribution to INARCH,
- and responding to the Call for Action of the WMO High Mountain Summit, October 2019

by

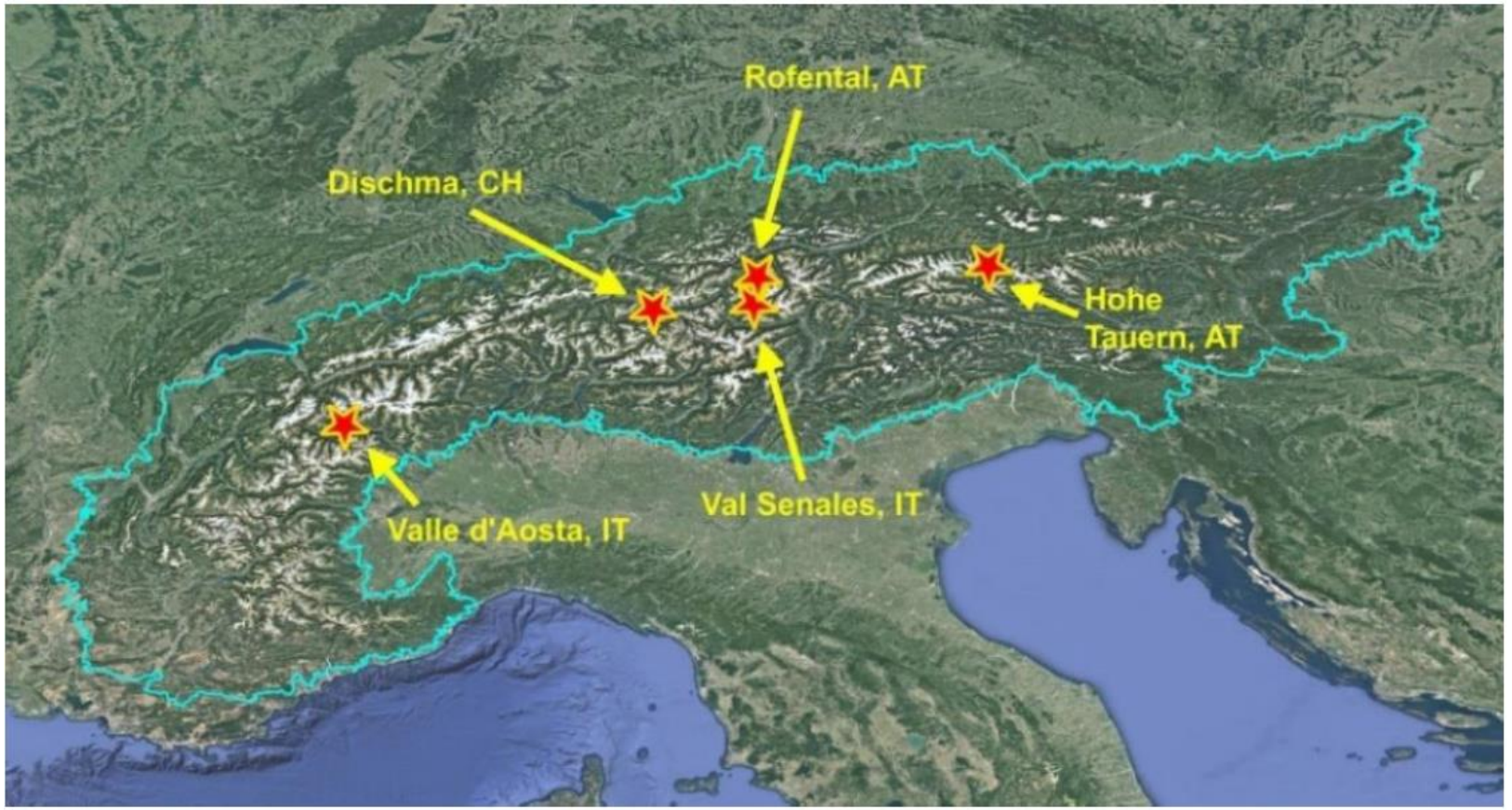
- generating at least 4 years of coherent, high resolution snow parameter products for the Alps
- evaluating potential impacts of the products on science, applications and society

AlpSnow product specifications

Product	Spatial Resolution	Sensor	Temporal Frequency	Accuracy	Validation
Snow area extent	20 m 300 m	Sentinel-2A/B S3 SLSTR & OLCI	3 days 1 day	< 20% FSC	In situ data of snow depth, Webcams, snow maps from very high resolution satellite images
Snow albedo	300 m	S3 OLCI PRISMA	1-2 days	< 5%	In situ measurements
Snow grain size	300 m	S3 OLCI PRISMA	1-2 days	TBD	In situ measurements during field campaigns
Snow melt area & wetness	100m	Sentinel-1	~3 days	5% of basin area	In situ weather data, numerical weather models (INCA), snow model data
Snow water equivalent	100 m	SnowGrid in synergy with S1, S2 and S3 L-Band SAR (PALSAR, SAOCOM)	3 hourly 14 -28 days	< 10%	In situ SWE measurements at stations and field sites
Snow depth	100 m	SnowGrid TanDEM-X repeat DEMs S1 C-Band PolRatio	3 hours when available ~6 days	< 10%	Snow depth at transects and stations

AlpSnow test areas

- include Dischma and Rofental INARCH research catchments
- covered by km-scale numerical weather prediction (INARCH class D IAOPS)



https://alpsnow.enveo.at