Status and Activities of INARCH Common Observing Period Experiment (COPE)

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Common Observing Period Experiment (COPE) 2022–2024

- COPE to focus on obtaining high-quality measurements to the extent possible
- Starting in 2022 to coincide with the start of the snow season in the southern hemisphere, and carrying on until 2024
- Ensure all sensors are working, enhance observations at our mountain research basins, fly supplementary UAV acquisitions, run high resolution models and work together for comparison of processes, data sharing, and model testing
- More details on COPE at https://inarch.usask.ca/science-basins/cope.php

COPE status

- Steering Committee has been formed to review and provide feedback on various field protocols and instrumentation plans, and to oversee planning and execution of various collective scientific endeavors stemming from the COPE
- online discussion was held on September 6, 2022 to go over the status and activities of COPE (this can be viewed at https://inarch.usask.ca/science-basins/cope.php#Fieldcampaignsitesresearchbasins)
- This showed that activities are well underway at many sites

Participating basins thus far

North America

South America

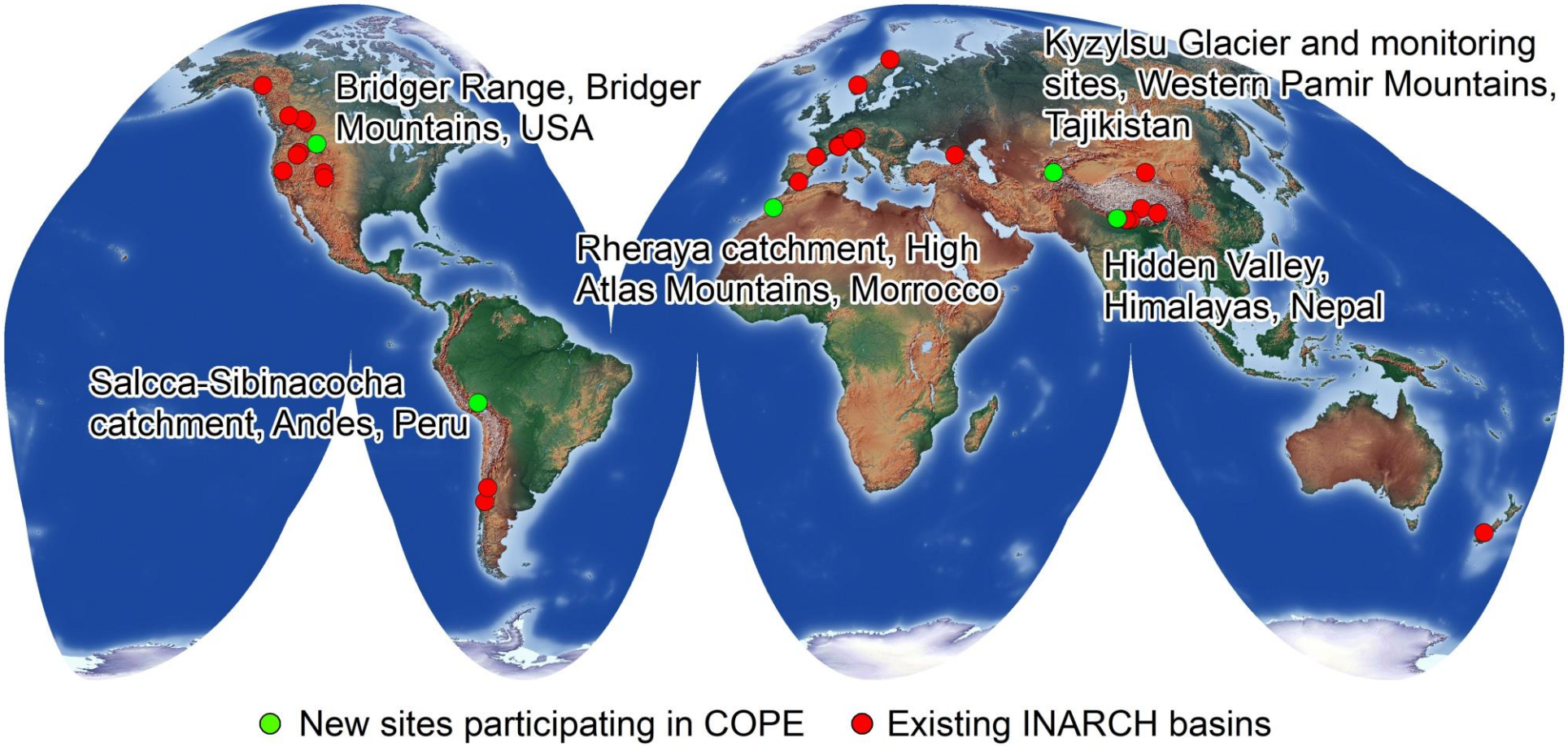
Europe and North Africa

23 sites in 14 countries and 6 continents

Central Asia

New Zealand

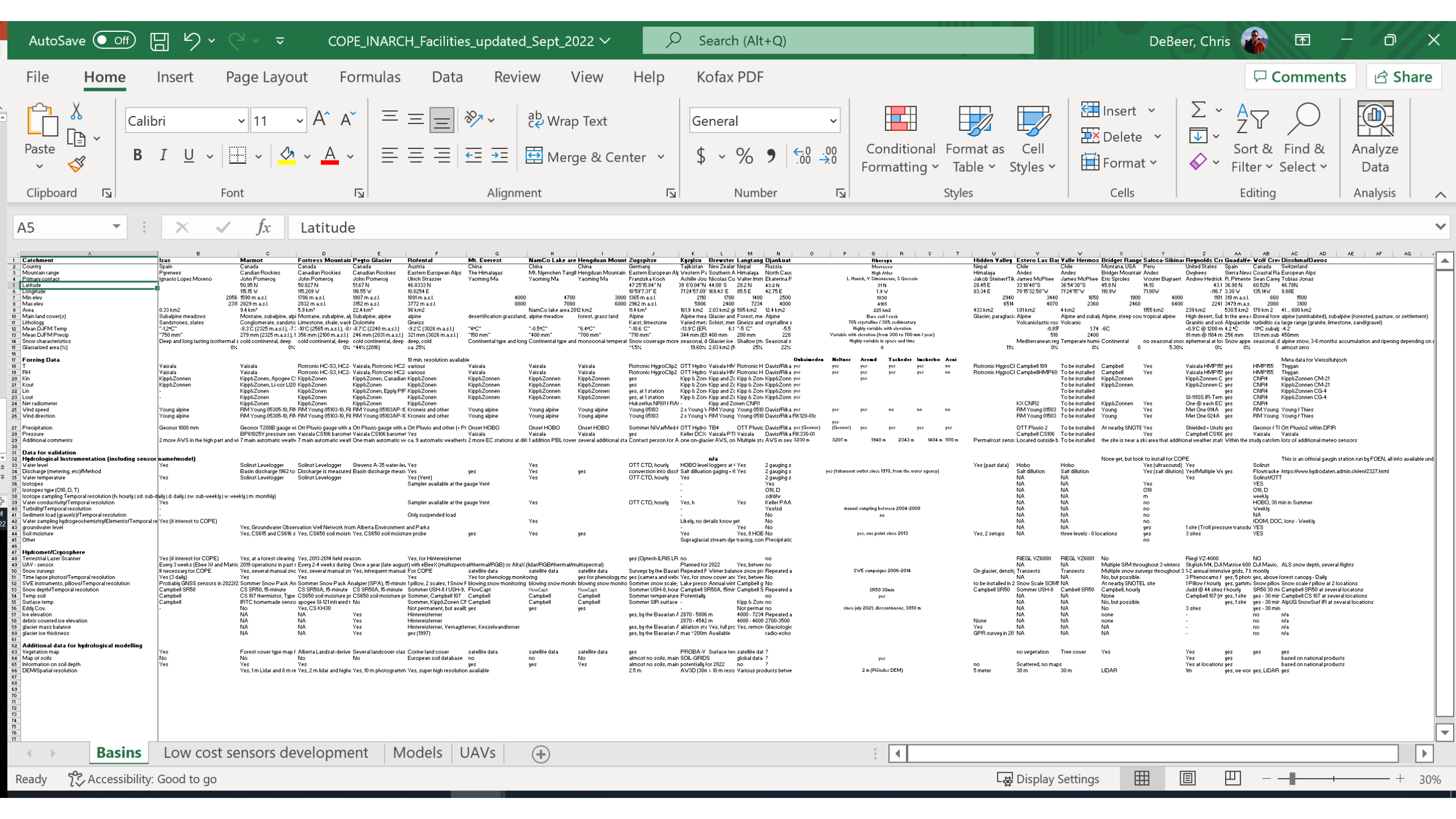
New sites to INARCH as of start of COPE



Shopping list (ideally)

- for each, need official name of research site/basin, contact person(s) or PI(s)
- geographic coordinates
- DEM and basin shapefile, landcover if available
- hydrometeorological and hydrometric observation stations (locations and details of all stations)
- papers, datasets (ESSD special issue), photographs
- What is the Integrated High Mountain Observing and Predicting Systems (IHMOPS) class? What are the measurement standards and the standards for field sampling? Need info on data schemes, data quality, data quantity?
- what models have been set up, run, and used for diagnosis and prediction of change? how have observational and experimental studies informed the development and application of models at the basin?
- what do the results show about how sensitive are catchment energy and water exchanges to climate and landcover change?
- what are the main uncertainties?

- Need to get all the data and information together--in GWFNet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DeBeer, Chris
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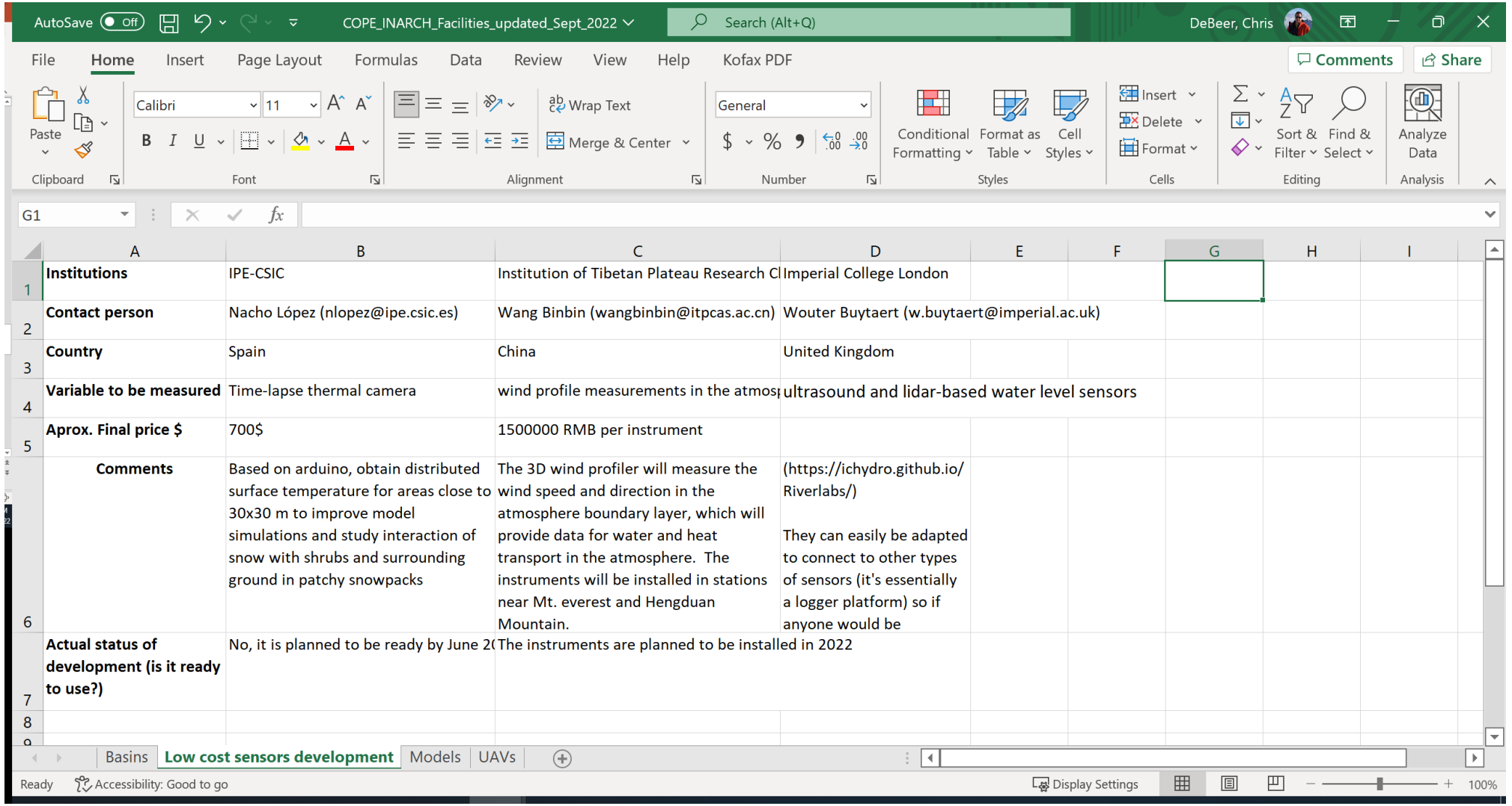
COPE activities

- The COPE will be enhanced with a suite of new and low-cost and more advanced sensors and drones to build and deploy at multiple sites to directly compare observations and gather a common data set (both instrument and site comparisons).
- Other sensors that are common across multiple sites (more expensive commercially available sensors) could also be compared.
- This will expand spatial coverage and allow broader participation, while more advanced technologies can be shared and deployed across sites.

Sensors



	A	B	C	D
1	**Institutions**	IPE-CSIC	Institution of Tibetan Plateau Research C	Imperial College London
2	**Contact person**	Nacho López (nlopez@ipe.csic.es)	Wang Binbin (wangbinbin@itpcas.ac.cn)	Wouter Buytaert (w.buytaert@imperial.ac.uk)
3	**Country**	Spain	China	United Kingdom
4	**Variable to be measured**	Time-lapse thermal camera	wind profile measurements in the atmos	ultrasound and lidar-based water level sensors
5	**Aprox. Final price $**	700$	1500000 RMB per instrument	
6	**Comments**	Based on arduino, obtain distributed surface temperature for areas close to 30x30 m to improve model simulations and study interaction of snow with shrubs and surrounding ground in patchy snowpacks	The 3D wind profiler will measure the wind speed and direction in the atmosphere boundary layer, which will provide data for water and heat transport in the atmosphere. The instruments will be installed in stations near Mt. everest and Hengduan Mountain.	(https://ichydro.github.io/Riverlabs/) They can easily be adapted to connect to other types of sensors (it's essentially a logger platform) so if anyone would be
7	**Actual status of development (is it ready to use?)**	No, it is planned to be ready by June 2(	The instruments are planned to be installed in 2022	
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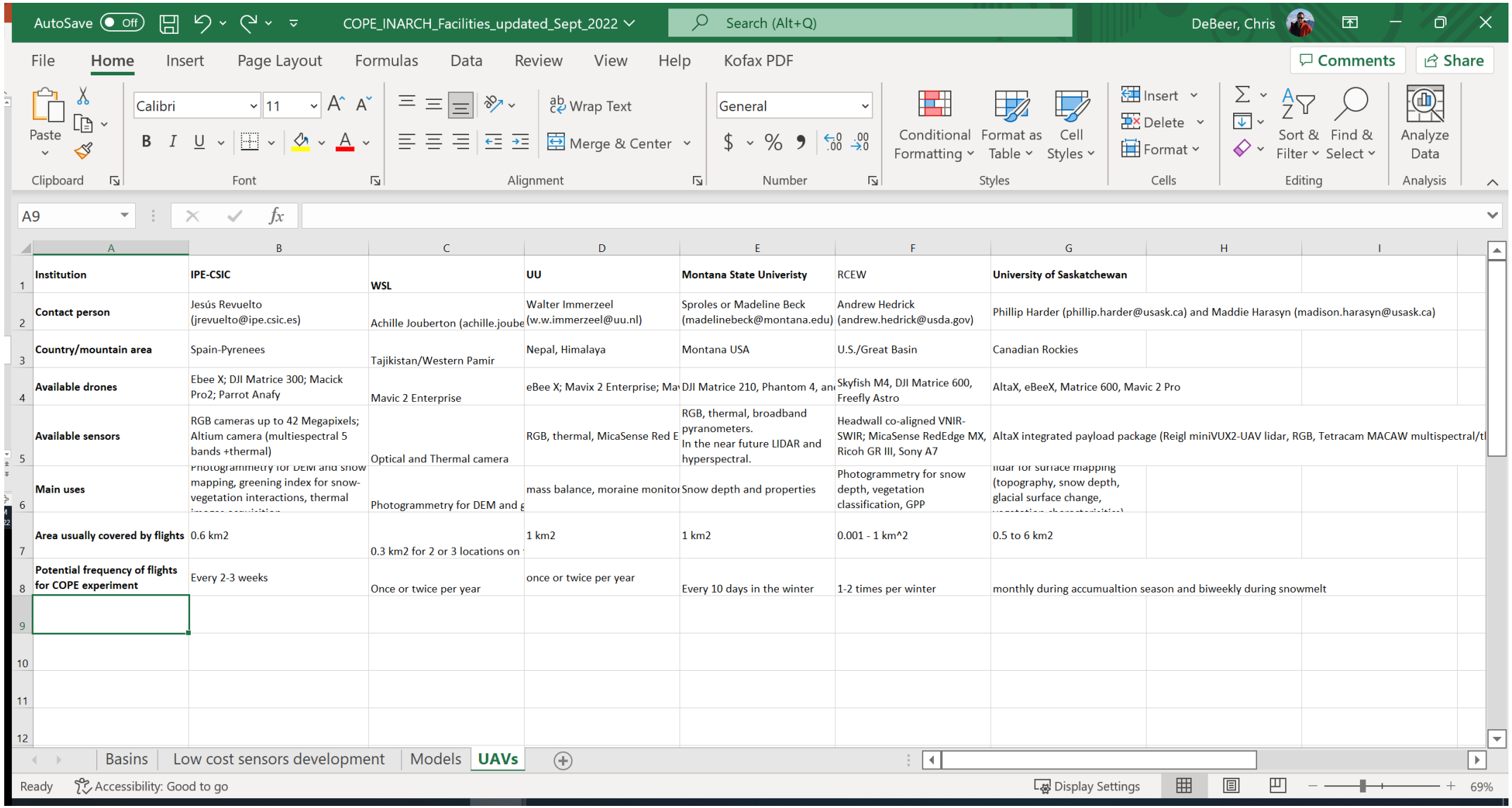
UAVs



	A	B	C	D	E	F	G
1	**Institution**	**IPE-CSIC**	**WSL**	**UU**	**Montana State Univeristy**	RCEW	**University of Saskatchewan**
2	**Contact person**	Jesús Revuelto (jrevuelto@ipe.csic.es)	Achille Jouberton (achille.joube	Walter Immerzeel (w.w.immerzeel@uu.nl)	Sproles or Madeline Beck (madelinebeck@montana.edu)	Andrew Hedrick (andrew.hedrick@usda.gov)	Phillip Harder (phillip.harder@usask.ca) and Maddie Harasyn (madison.harasyn@usask.ca)
3	**Country/mountain area**	Spain-Pyrenees	Tajikistan/Western Pamir	Nepal, Himalaya	Montana USA	U.S./Great Basin	Canadian Rockies
4	**Available drones**	Ebee X; DJI Matrice 300; Macick Pro2; Parrot Anafy	Mavic 2 Enterprise	eBee X; Mavix 2 Enterprise; Mav	DJI Matrice 210, Phantom 4, an	Skyfish M4, DJI Matrice 600, Freefly Astro	AltaX, eBeeX, Matrice 600, Mavic 2 Pro
5	**Available sensors**	RGB cameras up to 42 Megapixels; Altium camera (multiespectral 5 bands +thermal)	Optical and Thermal camera	RGB, thermal, MicaSense Red E	RGB, thermal, broadband pyranometers. In the near future LIDAR and hyperspectral.	Headwall co-aligned VNIR-SWIR; MicaSense RedEdge MX, Ricoh GR III, Sony A7	AltaX integrated payload package (Reigl miniVUX2-UAV lidar, RGB, Tetracam MACAW multispectral/t
6	**Main uses**	Photogrammetry for DEM and snow mapping, greening index for snow-vegetation interactions, thermal	Photogrammetry for DEM and g	mass balance, moraine monitor	Snow depth and properties	Photogrammetry for snow depth, vegetation classification, GPP	lidar for surface mapping (topography, snow depth, glacial surface change,
7	**Area usually covered by flights**	0.6 km2	0.3 km2 for 2 or 3 locations on	1 km2	1 km2	0.001 - 1 km^2	0.5 to 6 km2
8	**Potential frequency of flights for COPE experiment**	Every 2-3 weeks	Once or twice per year	once or twice per year	Every 10 days in the winter	1-2 times per winter	monthly during accumualtion season and biweekly during snowmelt
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Cope activities

- we plan to take a variety of different models and apply them in different basins to
  - see how they work,
  - make sure we have the proper forcing information,
  - try different forcing, at different scales,
  - see what corrections are needed for those forcings,
  - calculate snow and ice dynamics and hydrological dynamics at the surface, and
  - look at these diagnostically with available measurements from ice and snow changes, to soil moisture, streamflow, and turbulent fluxes, as available.
- This has not been done globally in alpine regions and could be potentially very powerful.

Models thus far

- Cold Regions Hydrological Model (CRHM), **https://research-groups.usask.ca/hydrology/modelling/crhm.php**
- openAMUNDSEN (distributed snow/ice/hydrological model), **https://doc.openamundsen.org**
- OGGM (open global glacier model), **https://oggm.org**
- Cosipy, **https://cryo-tools.org/tools/cosipy/**
- WRF\NoaaMP\CLM\LES models
- Canadian Hydrological Model (CHM), **https://github.com/Chrismarsh/CHM**
- FSM2 (can be run stand-alone or within CHM), **https://github.com/RichardEssery/FSM2**
- Thethys-Chloris, **https://doi.org/10.1029/2011MS000086**
- SPHY, **https://gmd.copernicus.org/articles/8/2009/2015/**
- AMelt, **https://doi.org/10.3390/geosciences11020078**
- SNOWPACK/Alpine3D, **https://models.slf.ch/**
- SnowModel, **https://journals.ametsoc.org/view/journals/hydr/7/6/jhm548_1.xml**
- AWSM/iSnobal, **https://github.com/USDA-ARS-NWRC/awsm**
- FSM-OSHD, github link to follow

For discussion

- How can we use COPE to address our INARCH Phase II objectives and answer our fundamental science questions?

INARCH Phase II Objectives

To better:

- measure and understand high mountain atmospheric, hydrological, cryospheric, biological and human-water interaction processes,
- improve their prediction as coupled systems,
- diagnose their sensitivities to climate change and propose how they may be managed to promote water sustainability under global change.

INARCH Phase II Science Questions

1. How different are the observation and measurement approaches amongst INARCH basins and do we expect distinctive differences in our understanding of basin response and hydrological predictability because of the sampling schemes, and data quality and quantity?
2. How do the predictability, uncertainty and sensitivity of energy and water exchanges vary with changing atmospheric thermodynamics, ecosystem structure and water management in various high mountain regions of the Earth?
3. What improvements to high mountain energy and water exchange predictability are possible through improved physics in, coupling of, and downscaling of models in complex terrain, and improved and expanded approaches to data collection and assimilation?
4. To what extent do existing model routines have global validity, are transferable, and meaningful in different mountain environments for providing service to society?
5. Can mountain systems be predicted and managed to find solutions to help achieve water sustainability in river basins under climate change?

Eventually contribute to answering - How have mountain atmospheric-cryospheric-hydrological-ecosystem-human systems co-evolved to their current states and how will they respond to climate change over the next century?