SPECIAL PROJECT PROGRESS REPORT

Reporting year	2019
Project Title:	Coupled energy and freshwater budgets from and early upper air data enhancements for reanalysis
Computer Project Account:	spatlh00
Principal Investigator(s):	Leopold Haimberger
Affiliation:	University of Vienna
Name of ECMWF scientist(s) collaborating to the project (if applicable)	D. P. Dee, Hans Hersbach, M. Balmaseda, P. Berrisford, S. Tietsche
Start date of the project:	1.1.2018
Expected end date:	31.12.2020

Computer resources allocated/used for the current year and the previous one

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	10000	0.06	10000	0.0
Data storage capacity	(Gbytes)	2000	32	2000	32

Summary of project objectives

The special project accompanies an Austrian Science Funds project devoted to evaluating the global energy budget, with emphasis on the Arctic. For this purpose access to experimental or not yet publicly available reanalysis data are needed. The project finishes in June 2019; a follow on project has yet to be funded. The second purpose of the project is to prepare early upper air data for assimilation into ERA5.

Summary of problems encountered (if any)

Summary of results of the current year (from July of previous year to June of current year)

In the past 12 months work on reducing numerical noise in the total energy budget evaluation has continued. While efforts are still ongoing in order to reduce the noise over high topography, While it is still there over high topography, a satisfactory state could be reached over the oceans. ERA5 data have been evaluated back to 2000, when CERES observations of top-of-the atmosphere radiation started.
Those results have been used in an in depth quantitative evaluation of the Arctic energy budget (Mayer et al. 2019). Using ocean heat content data from ORAS5, lateral oceanic energy fluxes towards the Arctic derived from moorings, atmospheric fluxes from ERA5, and CERES EBAF TOA net radiation, the energy budget residual could be significantly reduced from 25W/m^2 to 1W/m^2.

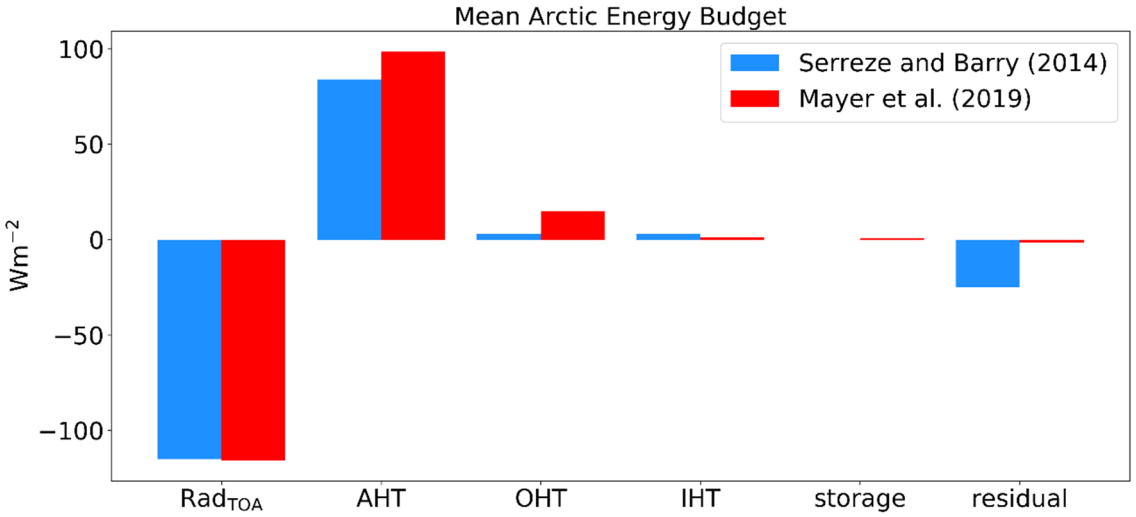

Fig. 1: Long-term mean estimates of relevant budget terms of the Arctic energy budget from Mayer et al. (2019) and Serreze and Barry (2014): Rad$_{TOA}$ denotes net radiation at top-of-the-atmosphere, AHT atmospheric heat transport, OHT oceanic heat transport, IHT latent heat transport associated with sea ice transports, long term energy storage (total of ocean and atmosphere warming and sea ice melt) and the residual, computed as the sum of all physical terms. Conversion factor to obtain TW is 10.51.

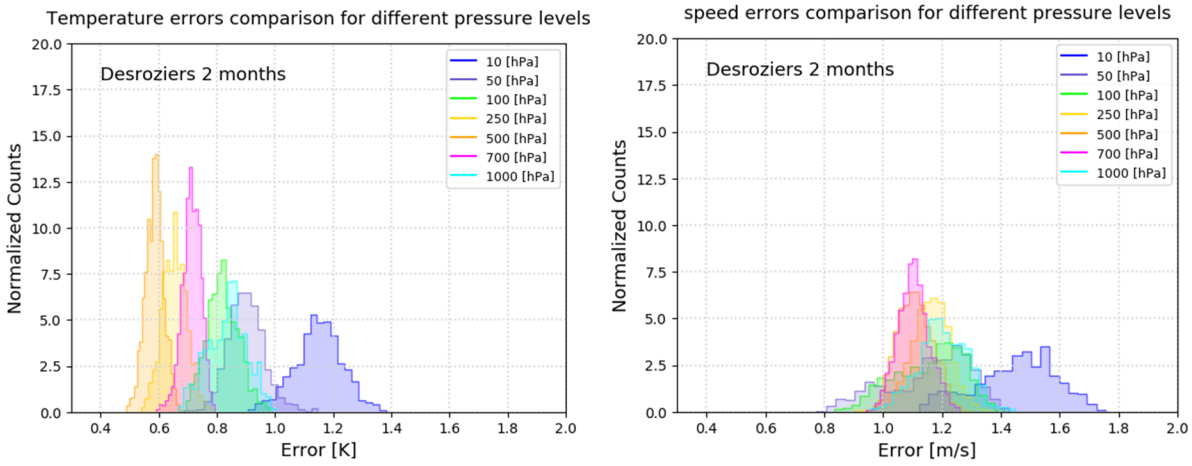

Fig. 2: Observation error estimates for temperature and wind from ERA5 using Desroziers (2005) statistics, for different pressure levels.

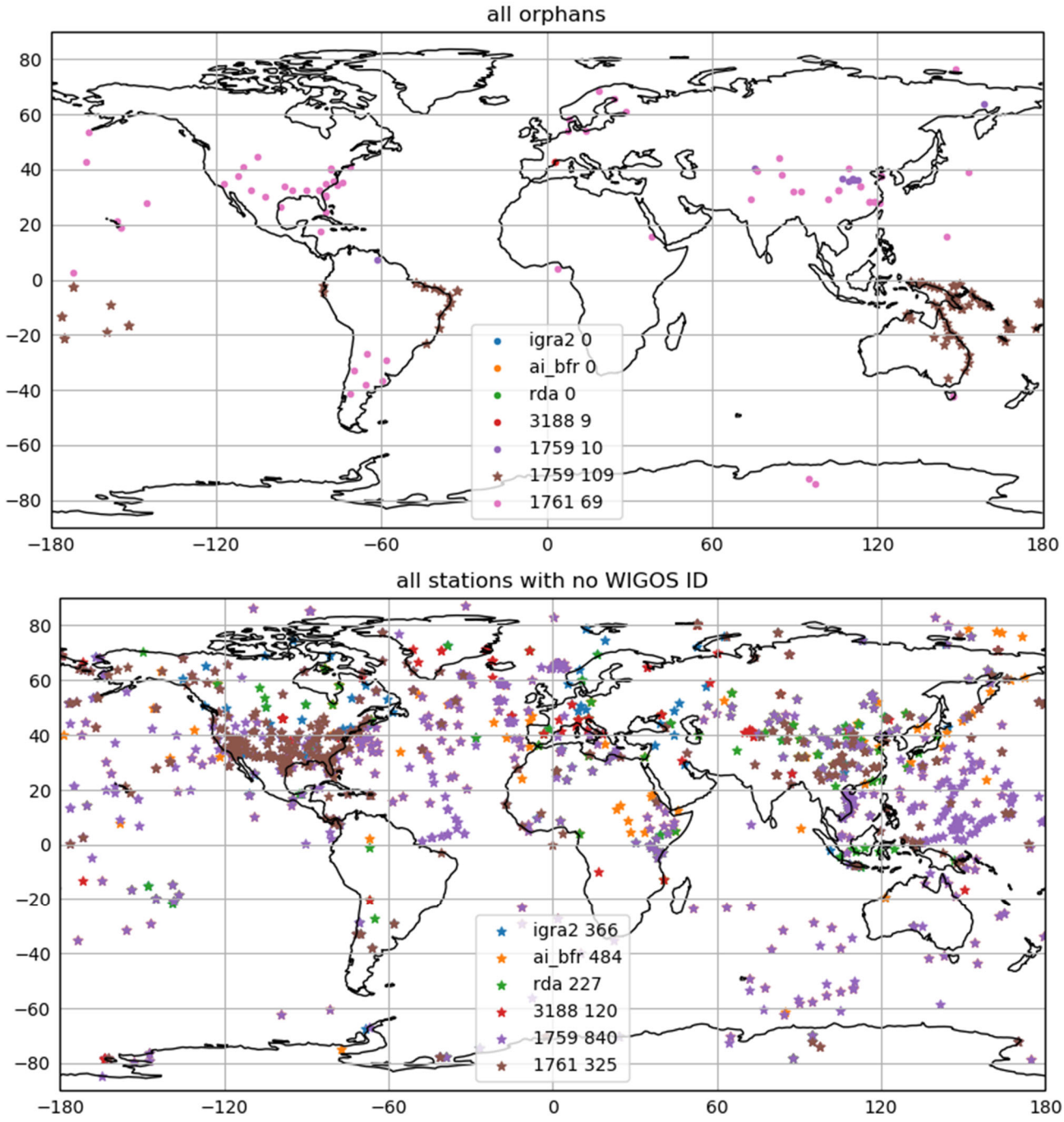

Fig. 3: a) Station records which could not be attributed to station metadata records in the ERA5 upper air observation input data sets. b) stations without WMO identifier. Those stations need to get a WIGOS identifier such that all upper air stations can be referred to from a single station numbering scheme.

In late 2018 funding from Copernicus could be secured to clean and analyze as well as bias correct early upper air data before 1979. Work concentrated on initial assessment of the observation error and on a comparison of data inventories with the actual data files. Fig. 2 shows histograms of estimated observation errors of temperature and wind at station Lindenberg for different years. These estimates correspond well with estimates from radiosonde intercomparison experiments. Fig. 3a shows locations of stations where data were found but that could not be identified in the station inventories. The main reason was a sign error in the latitude of WBAN stations on the Southern Hemisphere. Fig. 3b) shows stations who have no WIGOS identifier. Currently WIGOS identifiers are available only if it can be derived from a WMO station identifier. Note that in this plot the stations with missing minus in latitude are mirrored at the equator, most visible north of South America.

List of publications/reports from the project with complete references

Mayer, M., Tietsche, S., Haimberger, L., Tsubouchi, T., Mayer, J. and Zuo, H., 2019: An improved estimate of the coupled Arctic energy budget J. Climate 32, accepted subject to minor revisions.

Haimberger, L., M. Blaschek and F. Ambrogi, 2019: Early upper air station inventory version 0. Deliverable DC3S311c_Lot2.1.1.1 of Copernicus contract C3S 311c Lot2. 17pp.

Ambrogi, F., M. Blaschek and L. Haimberger, 2019: Wind uncertainties – initial assessment. Deliverable DC3S311c_Lot2.2.2.1 of Copernicus contract C3S 311c Lot2. 15pp.

Serreze, M. C., and R. G. Barry, 2014: *The Arctic climate system*. Cambridge University Press,.

Summary of plans for the continuation of the project

We will further analyse the noise problem in the budget calculations. Several ideas exist to reduce the noise, e.g. vertically variable distribution of the adjustments to the wind field needed for mass consistency or the removal of quasi-stationary noise signals at short wavelengths.

In the medium term global evaluations of the energy budgets as well as localized studies, e.g. over the western boundary currents, are planned. Those results will then be compared with CMIP5 and CMIP6 climate model runs.

The special project account will be used for fulfilling the obligations accepted within the Copernicus C3S-311c Lot2 contract.