

IASC ARCHES Workshop, Heriot-Watt University and Bruntsfield Hotel  
Edinburgh, Scotland, UK, 24-25 February 2014



## Global Change, Arctic Hydrology and Earth System Processes

### Workshop Summary Report

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### 1-paragraph description of the workshop and its outcomes

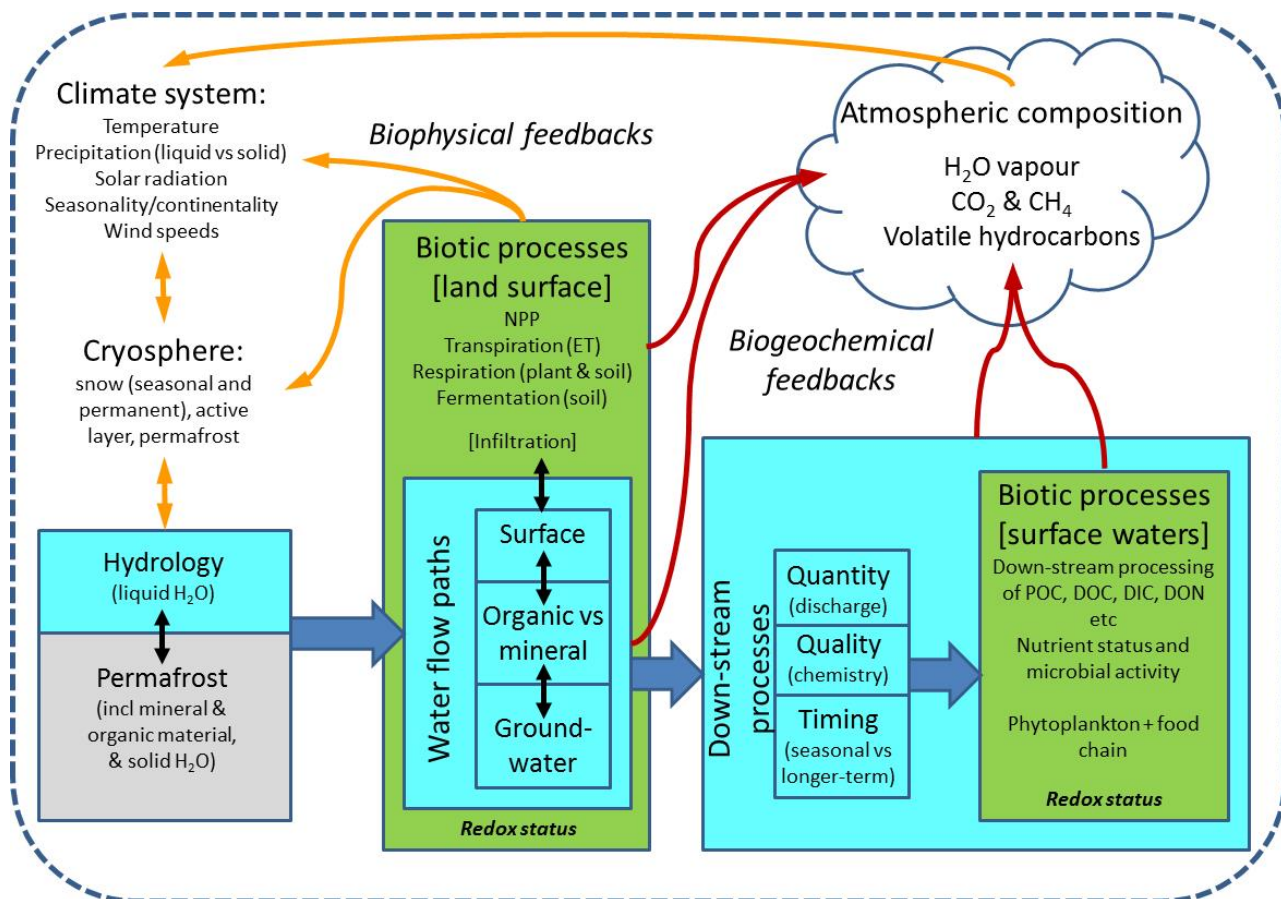
ARCHES aims to produce a synthesis/horizon-scanning paper for publication in a top international journal, as well as a policy briefing document for circulation at, and in advance of, ICARP III. The Workshop was held formally over two days, but work continues on manuscript drafting with the aim of submitting workshop outputs towards the end of 2014. Phase I (Pre-Workshop) involved workshop planning, literature review and circulation of materials, and initial synthesis; this took place between November 2013 and March 2014. Phase II (the Main Workshop, and 'Milestone I'; see Appendix A for the Agenda) involved presentations of key issues by participants, round-table discussion, initiation of drafting assignments and detailed planning for the review/position paper(s). Currently we are in Phase III (Post-Workshop) which involves drafting text at participants' home institutions, and Phase IV (Review at ASSW 2014, Helsinki, and Milestone II), in which a preliminary Workshop report was presented to the IASC Terrestrial WG.

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<sup>1</sup> In addition, Professor Doerthe Tetzlaff (University of Aberdeen) participated with separate funding

## Summary Report

This IASC initiative successfully brought together leading international experts and Early Career Scientists; ten people in person in Edinburgh, with additional input via correspondence from four others, and an Early Career Scientist who was unable to travel (at the last minute) due to illness. This was an enjoyable but challenging meeting, identifying key uncertainties in our understanding of the interactions between reported and predicted climatic and hydrological change in the Arctic, and biogeochemical (and, to a lesser extent, biophysical) processes of broader relevance to the Earth System. The **diagram below** (also submitted separately in Powerpoint format) summarizes how we intend to structure the main manuscript, emphasising (i) the interactions between permafrost and hydrology at hill-slope scales (left-hand column), (ii) the significance of changing water flow-paths for key biogeochemical processes (central column; 'Biotic processes [land surface]'), and (iii) down-stream processes in surface waters (right-hand column; 'Biotic processes [surface waters]'). We aim to focus on *process* understanding rather than modelling the Earth System, although the IASC WG structure provides us with a built-in mechanism to link with the other WGs in due course and to seek feedback for drafting policy statement(s) with a cross-cutting dimension. In this regard we are not restricted to working only with the Atmosphere and the Cryosphere WGs (in spite of the formulation of the diagram below) but there are links to both the Marine and the Social and Human WGs that we intend to explore. Furthermore, we believe that the 'process-focus' of ARCHES, at sub-grid and hill-slope scales, allows us to address key issues which complement (and can integrate) the related IASC initiatives 'THAW' (THERmokarst Aquatic ecosystems Workshop: Freshwater ecosystems in changing permafrost landscapes; <http://www.cen.ulaval.ca/thaw2014/>) and the AFS (Arctic Freshwater Synthesis; <http://www.iasc.info/home/networks/arctic-freshwater-synthesis>) network. Indeed the ARCHES



group includes key members from both initiatives (Vincent and Bring, respectively), allowing efficient dialogue.

Empirical work (coupling biogeochemistry/physics with permafrost and climate dynamics) all suggests that inter-annual and long term variations in hydrology are driving biogeochemical cycling and energy exchange to an extent where it is impossible to make any future projections without considering them. This conclusion to our discussions is an honest, if slightly gloomy, appraisal of the scientific community's current understanding, and goes some way to explaining why hydrological change, and its implications, is poorly-parameterised (at best) in coupled earth system models. Although "the undeniable result of permafrost thawing on continental scales will be net surface drying" (Hinzman et al. 2013<sup>2</sup>) there remains substantial uncertainty in modelling and predicting how changing permafrost and precipitation patterns (intensity, seasonality, and proportions falling as rain or snow) will affect surface and near-surface hydrological status and thermal regime at sub-grid and hill-slope scale; these are, however, critical controls on biogeochemical processes. Arctic warming and permafrost thawing may well increase the contrasts, on the local scale, between wet and dry parts of the landscape<sup>3</sup>. Acknowledging this, we intend to construct our ARCHES review paper around several tangible scenarios of change at these scales, and to explore the biophysical and biogeochemical consequences of these changes more broadly. This provides us with a mechanism systematically to address issues of scale, complexity and process relevant both to land-atmosphere coupling and fluxes of materials and energy, as well as land-freshwater coupling.

Manuscript drafting is on-going, although with several ARCHES participants involved in substantial fieldwork activities through the summer thaw period (and pre-field-season planning), including the lead author, we anticipate that progress will accelerate through the autumn of 2014.

In framing our review, some of the key questions we intend to address include:

1. What is the evidence of change on decadal timescales? [e.g. check/summarise IPCC/ACIA/SWIPA evidence/data, amongst others]
2. How well does modelling vs observational evidence intersect? Can we identify consensus on the direction and magnitude of change?
3. What do we know about the whole system (rather than case studies of component parts)? Can we currently link observations of hydrology, permafrost, greening etc in order to improve mechanistic process understanding? If so, then where, and over what timescales? Can we place key sites onto a diagram of environmental space (e.g. mean annual temperature vs precipitation) to highlight systems about which know something and to identify key gaps? How do we deal with the 'uniqueness of place' [Beven; *Hydrol. Earth Syst. Sci.*, 4, 203-213, 2000] in scaling-up?

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<sup>2</sup> Hinzman *et al.* (2013) Trajectory of the Arctic as an integrated system. *Ecological Applications*, 23(8), 1837–1868;

<sup>3</sup> Hinzman *et al.* (2013) *ibid.* "On the local scale, in a scenario in which near-surface soils become permafrost free, well-drained areas with low groundwater level (uplands) will become drier. At sites where the groundwater level is near the surface, soils may become wetter as permafrost degrades and the surface subsides."

4. How useful are large-scale global analyses of atmospheric composition (e.g. CO<sub>2</sub> and CH<sub>4</sub> concentrations) for identifying northern sources/sinks of key biogenic trace gases, or for integrating change (e.g. inverse modelling)?
5. Is the published literature structurally biased in favour of reporting change? How do we find out about areas/examples of stasis?
6. How useful is the palaeoenvironmental evidence of hydrological change in understanding contemporary interactions between climate, hydrology, permafrost and ecosystem processes/biogeochemistry, and predicting future change? Is the 'past the key to the future', or are we already well outside the environmental envelopes of the past? What about issues of scale or site-specificity?

When we have a full first draft of the journal manuscript we will solicit friendly review from members of other IASC WGs (and the related THAW and AFS initiatives); this is also the appropriate stage to work on related policy documents.

We thank IASC sincerely for funding this initiative, and will update on progress in due course.

Professor Philip A. Wookey, Edinburgh, April 2014

## Appendix A – Workshop Agenda

### Sunday 23 February

- Participants arriving (Bruntsfield Hotel); dinner at 7 p.m.

### Monday 24 February

- 09:15 – Meeting kick-off, Room PG 3.05, Postgraduate Centre
  - a. Introductions (ALL);
  - b. Review of the remit and purpose of IASC ARCHES, and reporting requirements (also for the Early Career Scientists) (PW);
  - c. Review and discussion of the homework/key themes (ALL);
  - d. Synthesis and consolidation with a view to manuscript drafting; group discussions of structure and unifying themes/diagrams etc (ALL).
- 17:15 – Formal Meeting Close (but on-going discussions through evening)

### Tuesday 25 February

- 09:15 – Meeting continues in Room MB G.33 (Mary Burton Building)
  - e. Brief review of progress (PW);
  - f. Manuscript planning; identification of key topics and assignment of drafting tasks (ALL);
  - g. Drafting groups convene across campus (no rooms assigned for this, but my office can be used, and there are plenty of communal spaces around campus) (ALL);
  - h. Reporting back (ALL) – Room MB G.33;
  - i. Refinement of structure and allocation of post-workshop tasks/timeframes (ALL).
- 17:15 – Formal Meeting Close

### Wednesday 26 February, **and subsequently**

- Remaining participants depart; ARCHES work continues! ARCHES progress report to IASC at ASSW2014 (Arctic Science Summit Week), Helsinki, 5-8 April 2014; completion of ARCHES manuscript for submission in the final quarter of 2014.