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NRC PERD 079 Project - Task 1 - Findings from the Inuvit NT survey

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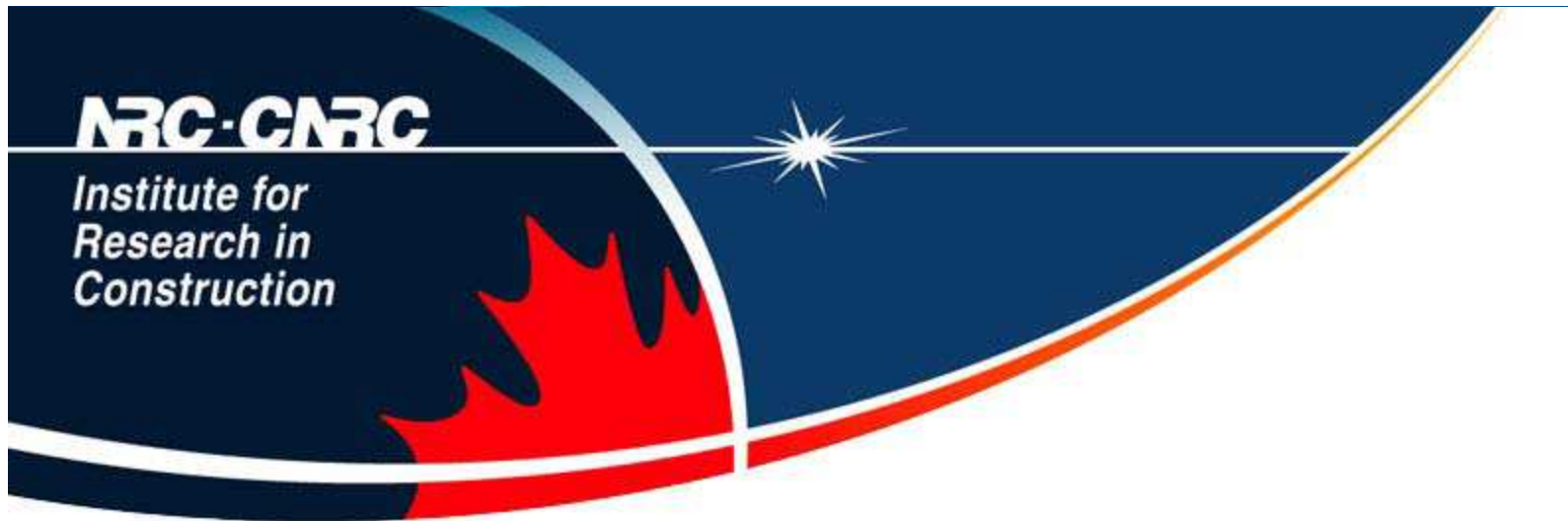
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NRC PERD 079 Project- Task 1

**Findings from the Inuvik NT Survey
prepared by
Madeleine Rousseau, Marianne Manning,
Nady Said, Mike Swinton and Steve Cornick
Feb. 2007**



National Research
Council Canada

Conseil national
de recherches Canada

Canada

Inuvik Survey

- In 2005 Arctic Energy Alliance in Yellowknife was contracted out to carry out the survey
- Support from the NT Housing Corporation and Inuvik housing Corporation was provided
- 8 houses/region
 - 4 with reported moisture troubles
 - 4 without reported moisture troubles
 - Inuvik survey was carried out from November 18 to December 18, 2005

Data Collection

- Hobo RH and T sensors
 - calibrated at IRC (up to about 60% RH)
 - 2 indoors per house
 - On wall of room with high moisture source or with identified moisture problem. Kitchens and bathrooms
 - One out of 16 indoor sensors did not work
 - one outdoors per survey region
 - Set to capture data every three minutes
- EnerGuide for Houses survey, fan depressurization test and Hot 2000 analysis
- IRC-made questionnaire on basic building characteristics

House Characteristics

- Moisture problems:
 - Frost built up on windows and bottom of doors
 - Cracks allowing air infiltration
 - Mould growth
 - Water damage underneath windows
- Built between 1976 and 1986
- 7 wood-frame 2X6 and 1 log home
- Mix of detached, semi and row housing, 1 and 2 storeys
- Range of airtightness levels (4-12 ACH @ 50 Pa)
- Occupancy varied between 3 to 5 persons
- Natural gas heating. Either hot water heat distribution or forced air
- Double glazed PVC windows
- Manually-operated exhaust fans in kitchen and/or bathroom

House Characteristics

House	ACH @ 50 Pa	EGH rating (Age of construction)	Max indoor RH recorded	Occupancy load (day/night)
524 MT (#1)	6.9	69 (1977)	80 & 99%	4 occupants (2/4)
525 MT (#2)	3.6	68 (1977)	68 & 97%	5 occupanst (1/4)
526 (#3)	6.3	64 (1985)	79 & 99%	3 occupants (0/3)
527MT (#4)	9.2	53 (1975)	52 & 99%	5 occupants (5/5)
528 (#5)	10.9	60 (1975)	61 & 99%	3 occupants (1/3)
529MT (#6)	12.2	53 (1977)	34 & 99%	3 occupants (2/3)
530 (#7)	12.2	58 (1986)	39 & 99%	5 occupants (1/5)
531 (#8)	4.5	69 (1979)	82 & 100%	3 occupants (1/3)

No-Moisture-problem Sample Characteristics

Non-Moisture Troubled Sample									
House No.	Hobo sensors & location	No. of occupants (day/night)	Windows	Humidifier	House-general	Heating system	Ventilation	EGH rating / ACH @50 Pa	Problems
526 (#3)	840008: Kitchen 840003: Bathroom	3 (0/3)	Vinyl sliders	No	Built 1985 2 storey 2-bedroom semi-detached Open crawl space	Shared natural gas boiler Hot water heat distribution	Manually-operated exhaust fan in kitchen	64/6.3	Frost on window panes and bottom of ext. doors Windows are leaky Ice buildup on fresh air intake vent
528 (#5)	840004:kitchen 840012:bathroom	3 (1/3)	Vinyl sliders	No	Built 1975 2 storey 2-bedroom semi-detached Open crawl space Log home	Natural gas furnace Heated mechanical space under floor Forced air heat distribution	Manually-operated exhaust fan in bathroom	60/10.9	Ice on windows around dryer vent and plumbing stack No mould growth observed
530 (#7)	840010:kitchen 840009:bathroom	5 (1/5)	Vinyl hinged	No	Built 1986 2 storeys 3 bedroom rowhouse open crawl space	Natural gas furnace	Manually-operated exhaust fan in bathroom and kitchen	58/12.2	Air leakage at windows and penetrations No mould growth observed
531 (#8)	840005:kitchen 839995:bathroom	3 (1/3)	Vinyl hinged	No	Built 1979 2 storeys 2 bedroom semi-detached open crawl space	Shared natural gas boiler	Manually-operated exhaust fan in bathroom	69/4.5	Air leakage around door, dryer vent and penetrations frost buildup on windows Cracks in the walls

Moisture problem Sample Characteristics

Moisture-Troubled Sample									
House No.	Hobo sensors & location	No. of occupants (day/night)	Windows	Source of humidification	House-general	Heating system	Ventilation	EGH rating / ACH @50 Pa	Problems
524 (#1)	840007: kitchen 840001: Bathroom	4 (2/4)	Vinyl sliders	No	Built 1977 2 bedroom semi-detached one-storey. Open crawl space	Shared natural gas boiler Hot water heat distribution	Manually-operated fans in bathroom and kitchen	69/6.9	Dew, frost and mould growth forming on windows in LR Water damage under windows Mould growth and staining in bathroom Ice buildup on exterior door
525 (#2)	840013: kitchen 840000: bathroom	5 (1/4)	Vinyl sliders	No	Built 1977 4 bedroom detached 2 storeys Open crawl space	Natural gas boiler Hot water heat distribution	Manually-operated fans in bathroom and kitchen	68/3.6	Minor dew and frost forming on windows Water damage at window sill in LR Air infiltration around windows and outlets. No mould growth observed
527 (#4)	840011: kitchen 8400006: bathroom	5 (5/5)	Vinyl sliders	No	Built 1975 4 bedroom row house Open crawl space	Shared natural gas boiler Hot water heat distribution	Manually-operated fans in bathroom	53/9.2	Frost on windows and water damage under windows and at sill/jambs in bedrooms Cold air infiltration around windows, at wall/ceiling junctions and at exhaust fan Mould growth observed around window frames
529 (#6)	839999: kitchen 839996: bathroom	3 (2/3)	Vinyl sliders	No	Built 1977 2 bedroom one-storey detached Open crawl space	Natural gas furnace Heated mechanical space under floor Forced air heat distribution	Manually-operated fans in bathroom	5/12.2	Air infiltration around windows, at penetrations, doors and exhaust fan Some moisture damage in bathroom /bedroom window No mould growth observed





524(#1)MT
EGH: 69



527 (#4) MT
EGH: 53



525 (#2) MT
EGH: 68



529 (#6) MT
EGH:53

Non Moisture Troubled (NMT) Houses



526 (#3) NMT
EGH: 64



528 (#5) NMT
EGH: 60

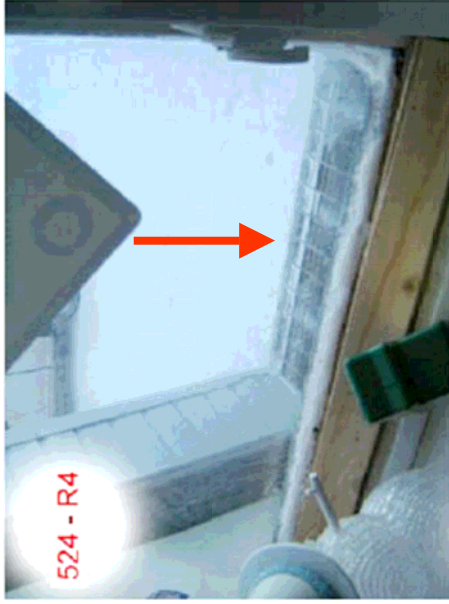


530 (#7) NMT
EGH: 58



531 (#8) NMT
EGH: 69

Types of Moisture Troubles



Types of Moisture Troubles



527 - R5



527 - R6

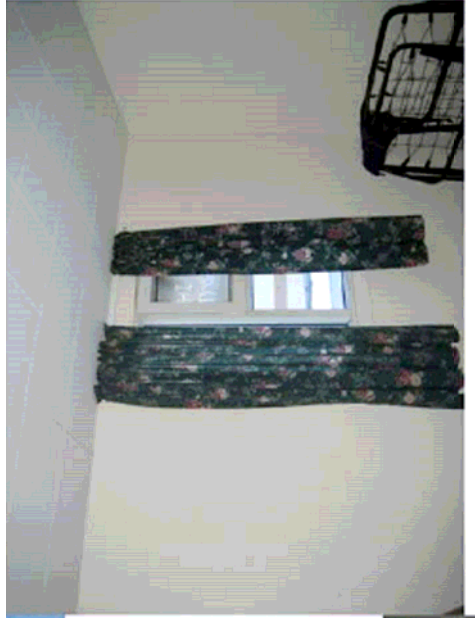
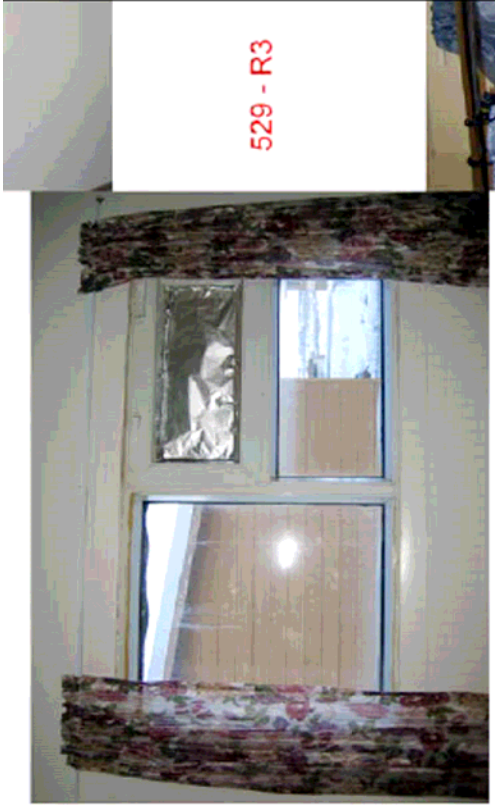


527 - R7

528 - R4



Types of Moisture Troubles



Sensor Locations



524 (1b) Bathroom



525 (2a) Bathroom



526 (3a) Bathroom



525 (2b) Kitchen



526 (3b) Kitchen

Sensor locations



527 (4a) Bathroom



528 (5a) Bathroom



529 (6a) Kitchen



527 (4b) Kitchen



528 (5b) Kitchen

Sensor locations



530 (7b) Kitchen



531 (8a) Kitchen



Outdoor sensors



531 (8b) Bathroom



Data Analysis

- Average outdoor RH and T in Inuvik during the survey period
- Average daily Temperature in NMT and MT relative to outdoors
- Average indoor RH in NMT and MT relative to outdoor and type of room
- Characteristics and duration of high humidity events

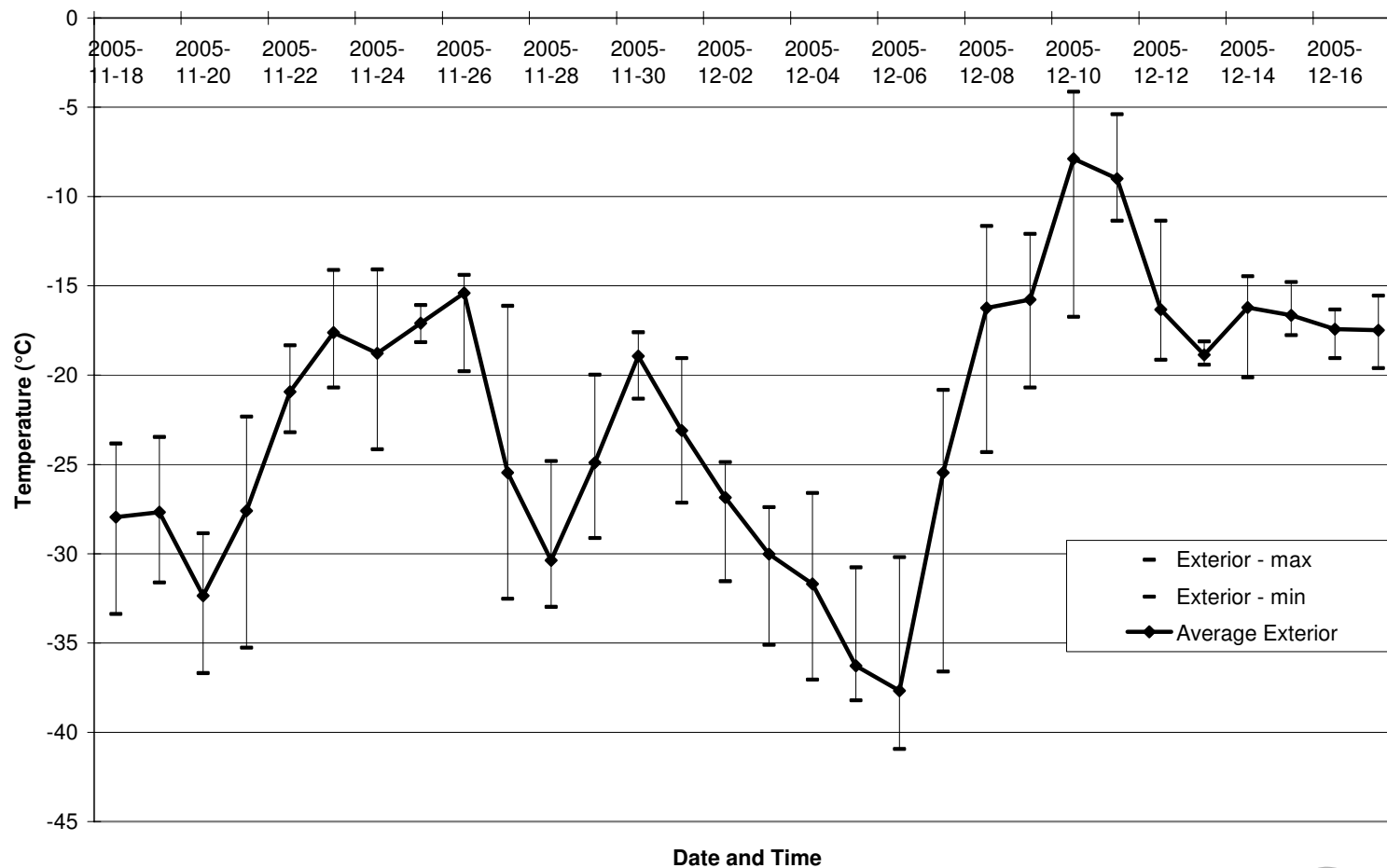
Very cold: T_{ext} mostly below -7°C

Min T_{ext} reached -40°C

Exterior Average Daily Temperature

INUVIK

Exterior - Daily Temperature

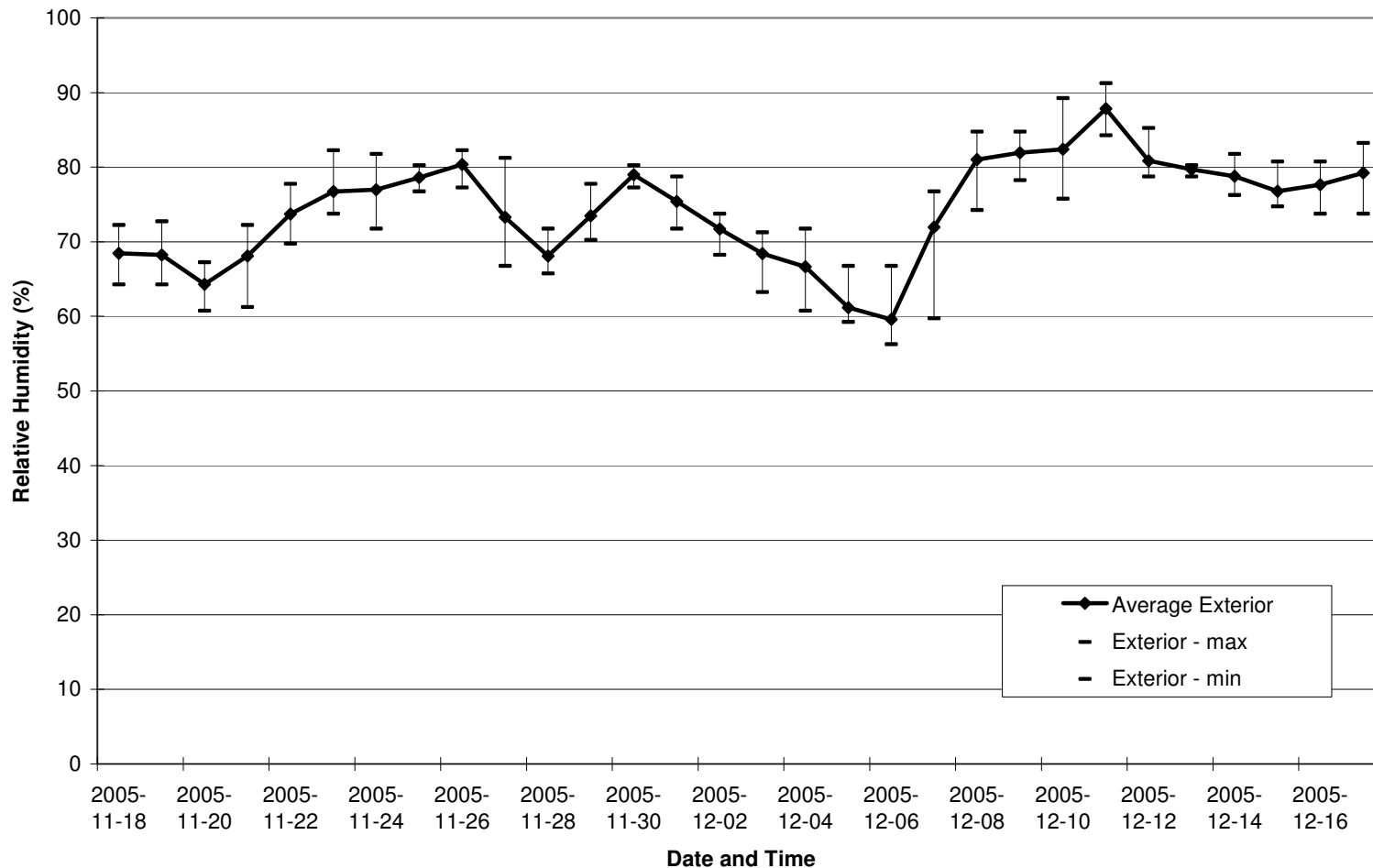


Fairly humid (55-90%RH)
Humidity ratio less than 1.5 g/Kg

Exterior Average Daily RH

INUV

Exterior - Daily Relative Humidity

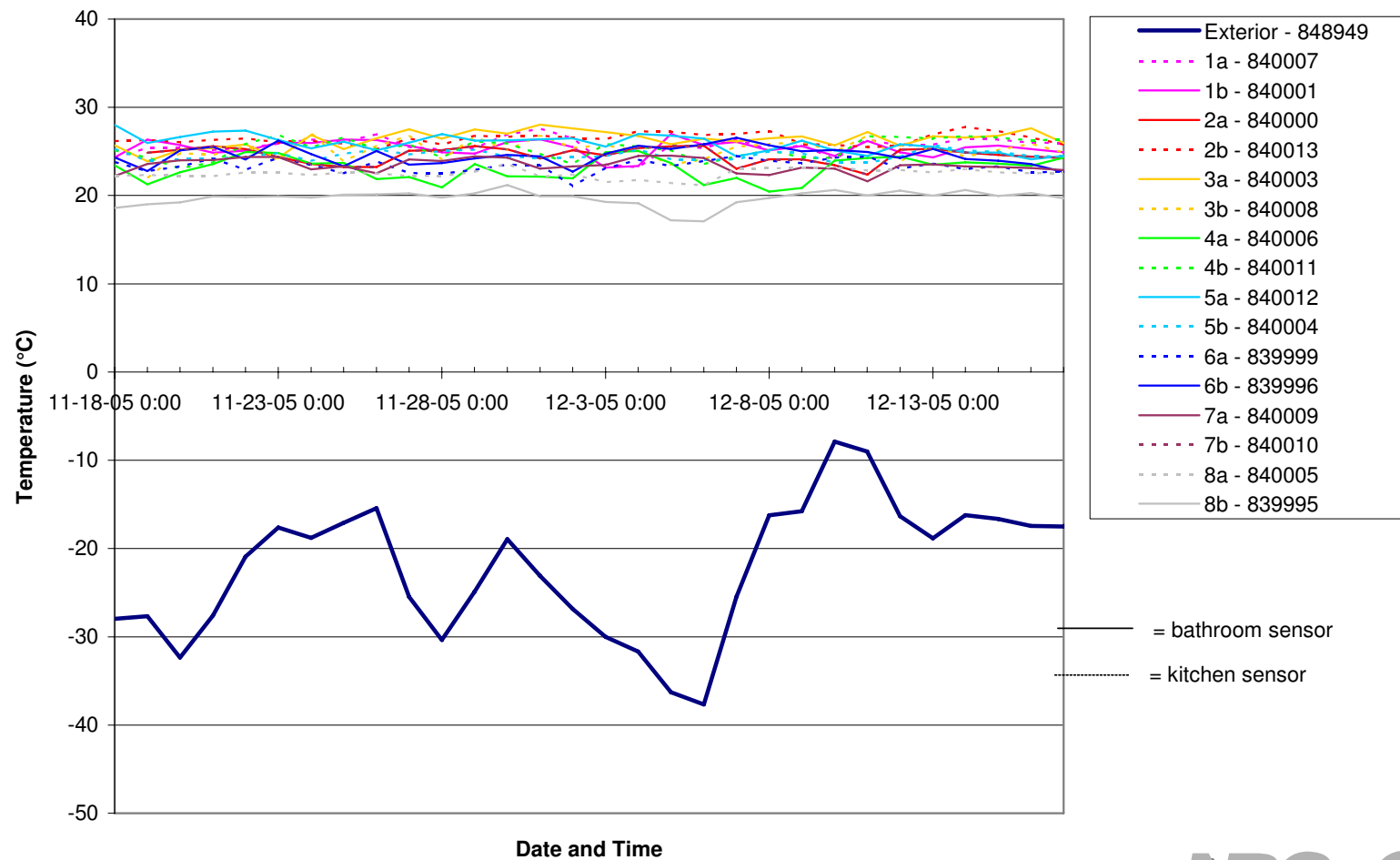


•Daily averages of indoor T not much influenced by outdoor T

Average Daily Temperature All Houses

INUUVIK

Average Daily Temperature

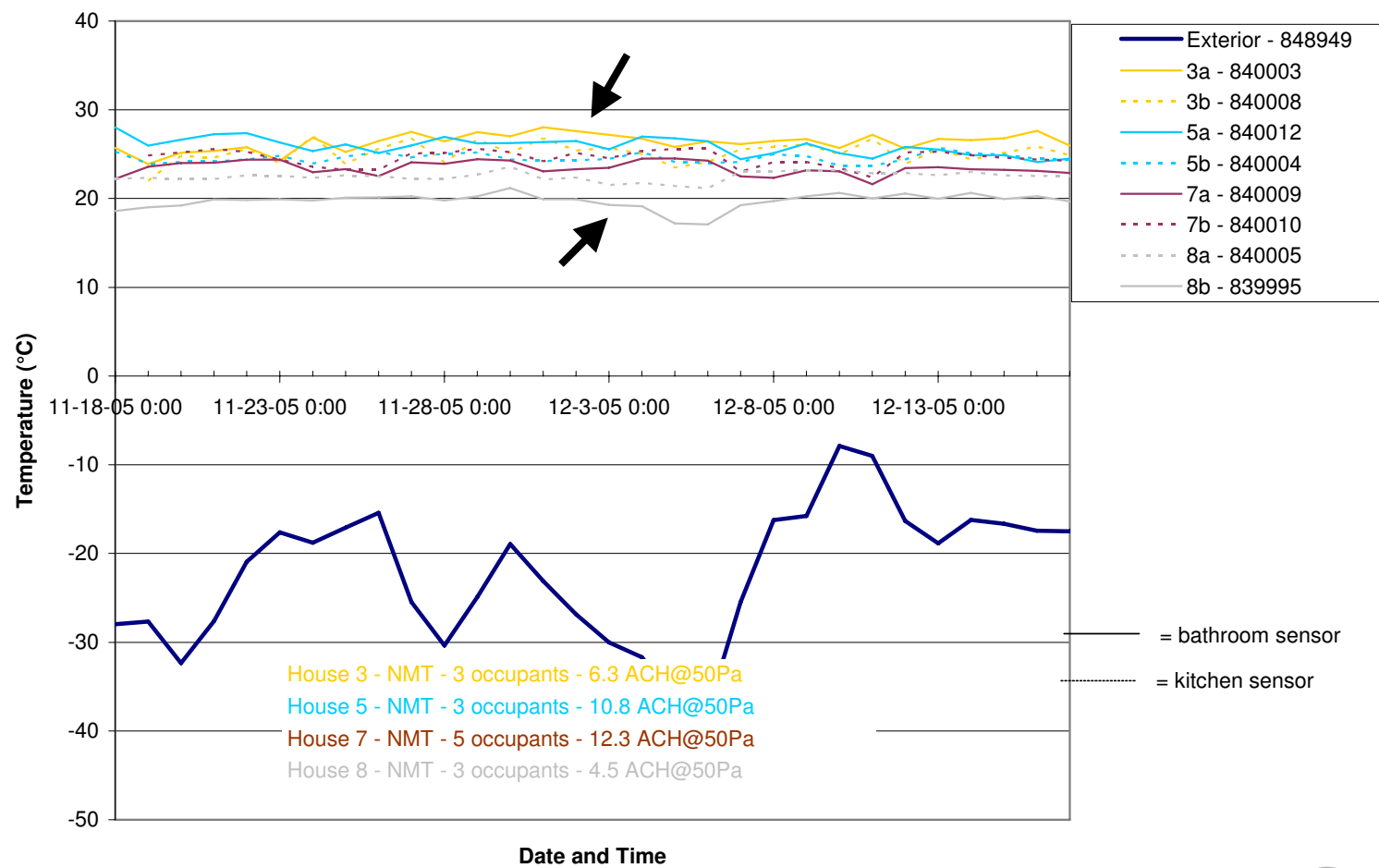


- House 8 (bathroom) was cooler
- House 3 (bathroom) ran warmer

Temperature Non Moisture Troubled Houses

INUVIK

Average Daily Temperature - Non Moisture-Troubled Houses

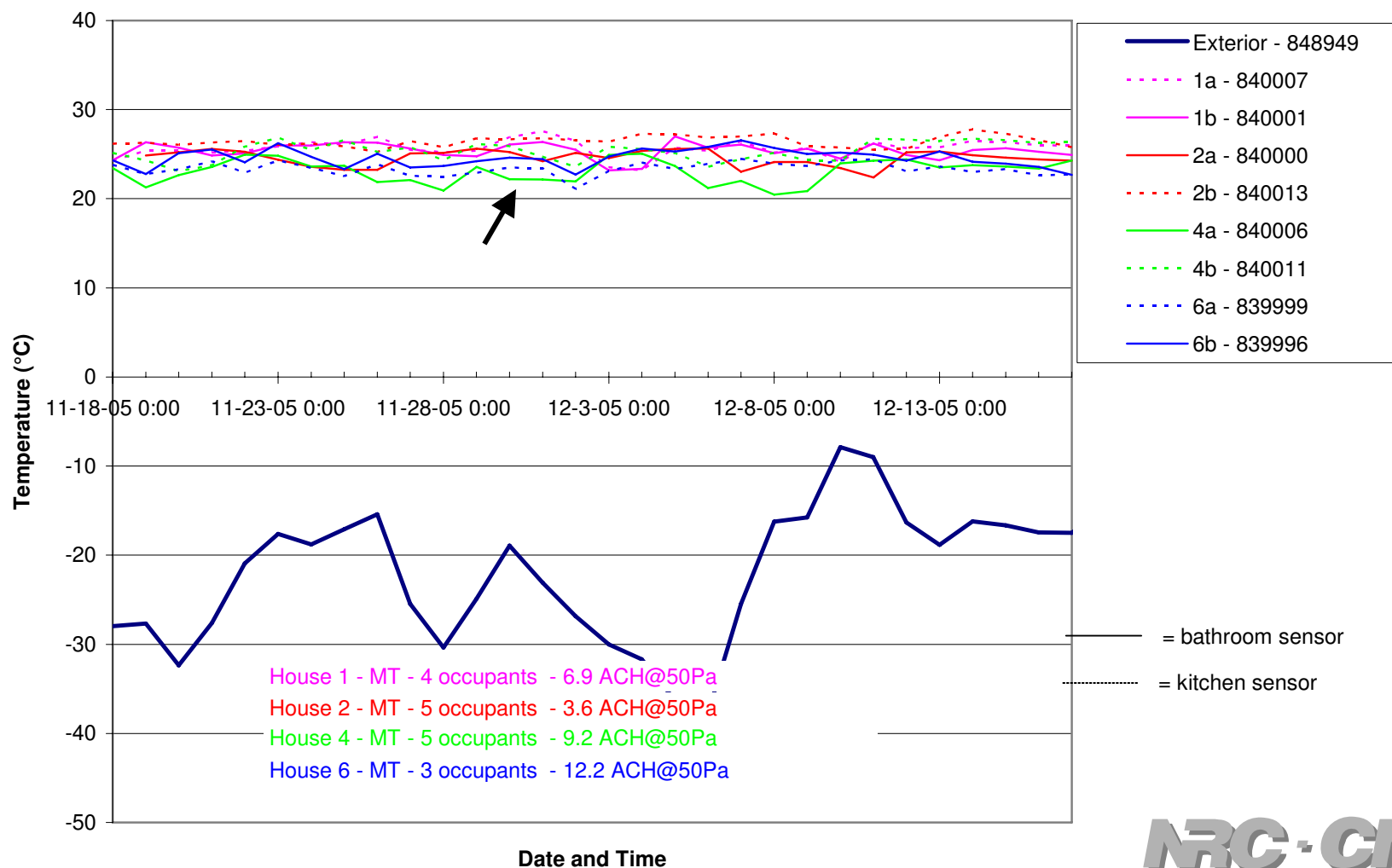


- Narrow band of average daily T
- House 4 (bathroom) was slightly cooler

Temperature Moisture Troubled Houses

INUVIK

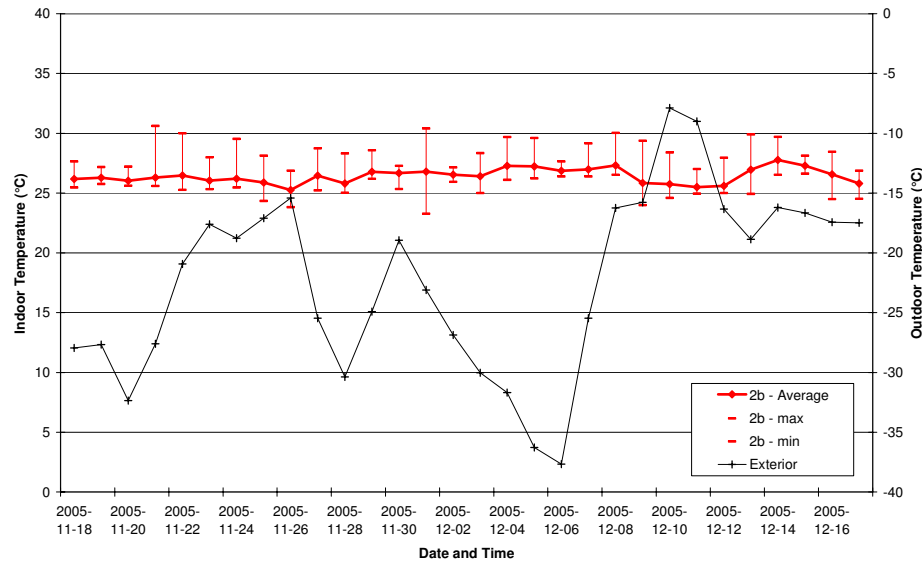
Average Daily Temperature - Moisture-Troubled Houses



INU

EGH525 - 2b - Daily Temperature Kitchen

House 2 - MT* - 5 occupants - 3.6 ACH@50Pa - kitchen sensor



Min and Max of Temperature

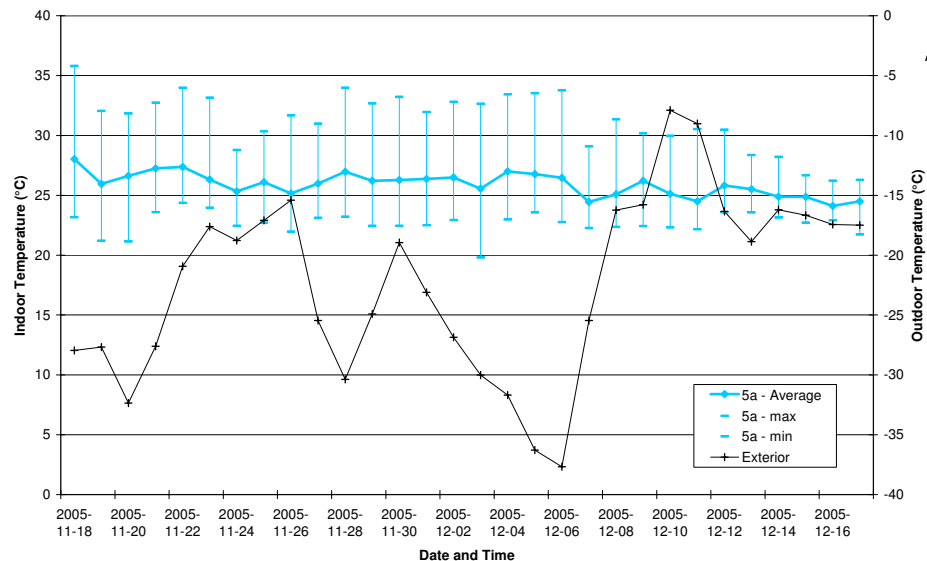
House	Min-max T (C)
#1	21-31 21-30
#2	23-31 5-30
#3	10-33 22-31
#4	19-29 18-27
#5	20-30 20-36
#6	17-28 17-32
#7	10-29 21-27
#8	20-26 16-24

Larger T fluctuations in bathrooms than kitchen

INU

EGH528 - 5a - Daily Temperature Bathroom

House 5 - NMT - 3 occupants - 10.9 ACH@50Pa - bathroom sensor

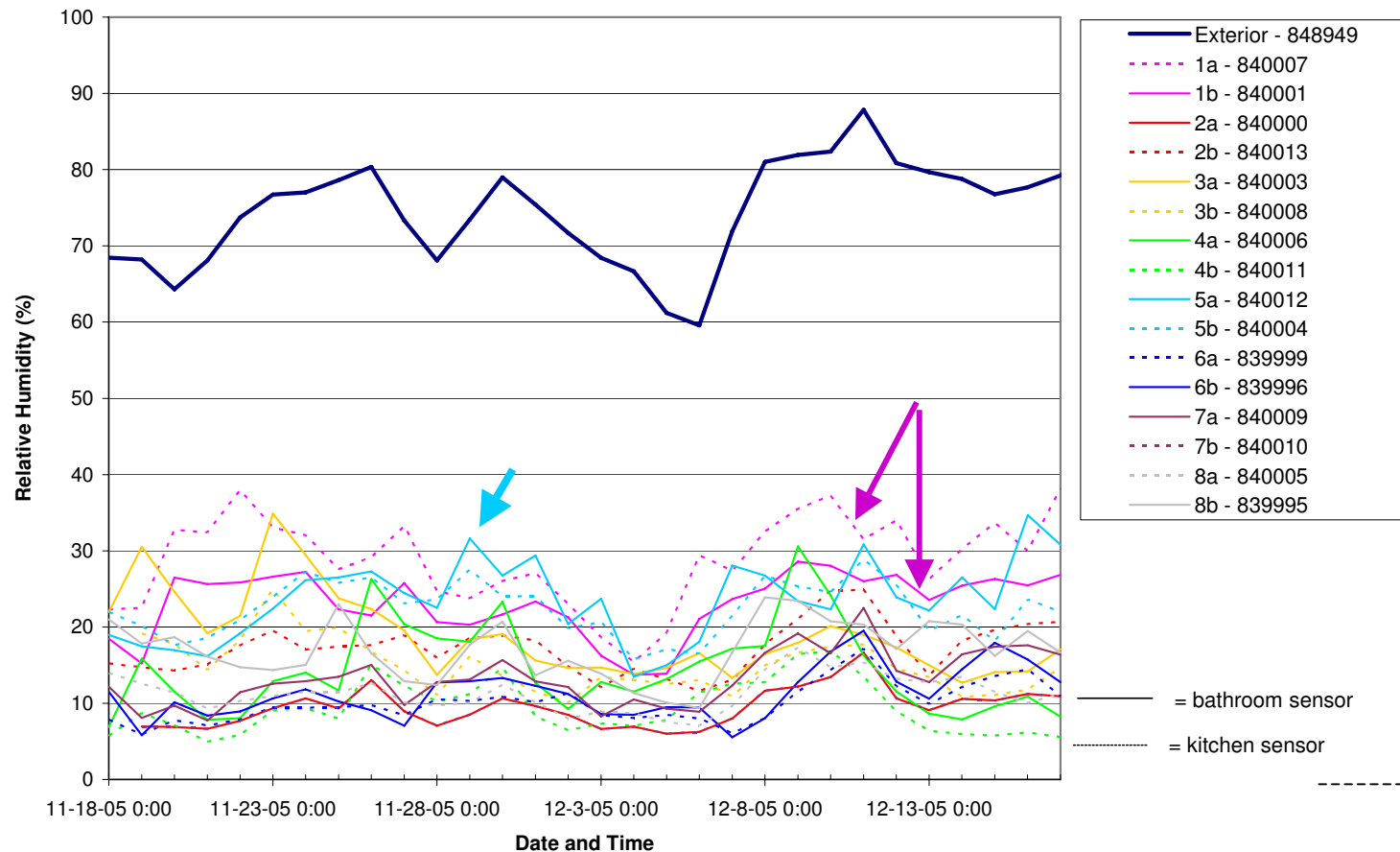


- Houses #1 and # 5 have indoor RH with some resemblance to outdoor RH
- Daily averages of indoor RH is low (below 40%)

Daily Average Relative Humidity in All Houses

INUVIK

Average Daily Relative Humidity



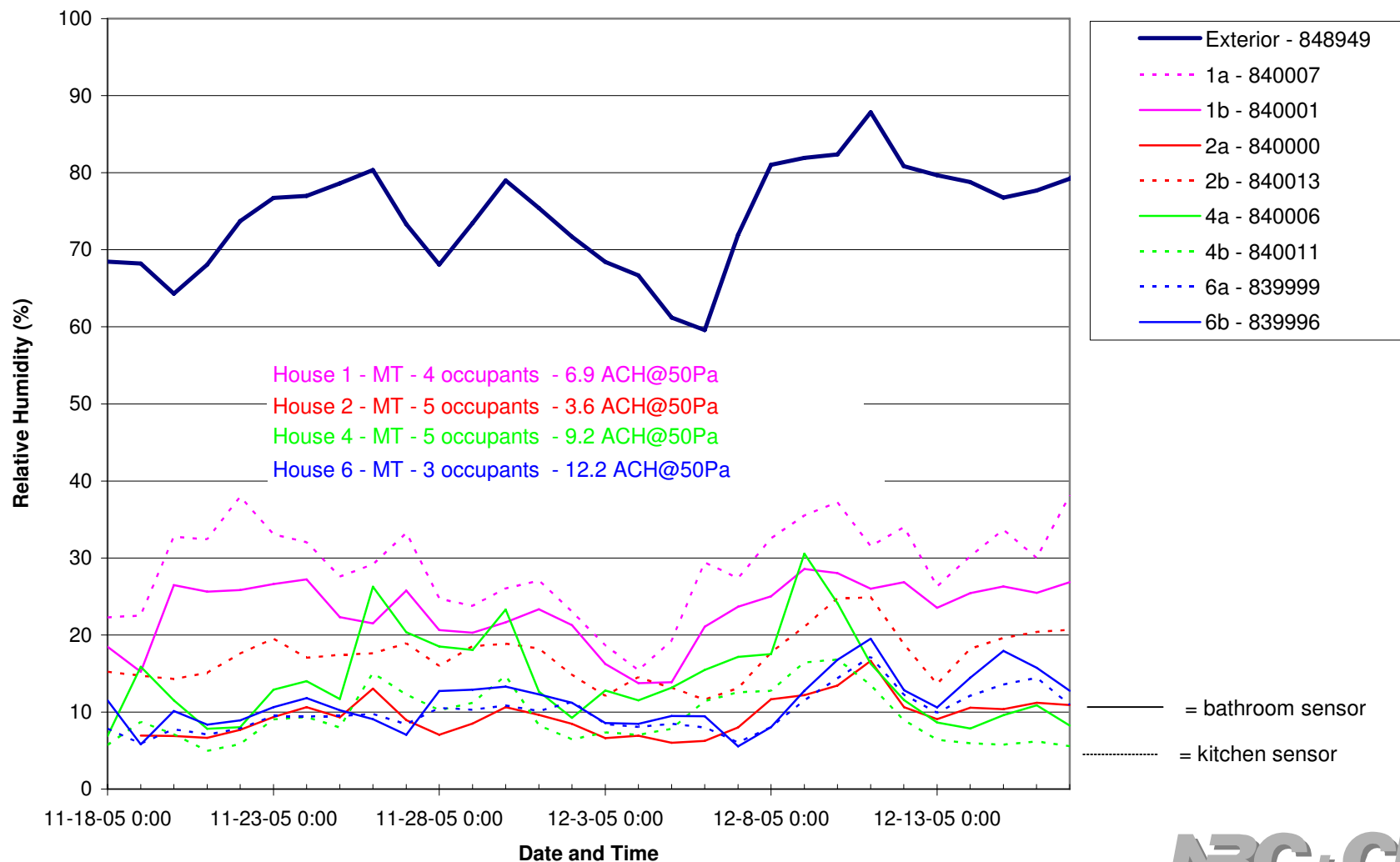
Follows outdoor RH trends?

Daily averages of indoor RH is low (below 40%)

Indoor RH in Moisture Troubled Houses

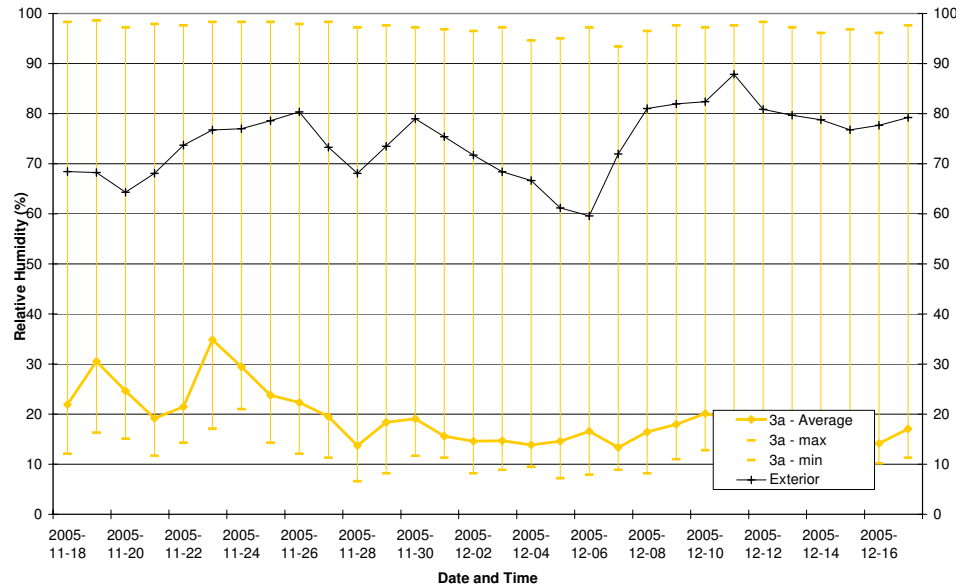
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Average Daily Relative Humidity - Moisture-Troubled Houses



Bathroom (NMT) EGH526 - 3a - Daily Relative Humidity

House 3 - NMT - 3 occupants - 6.3 ACH@50Pa - bathroom sensor



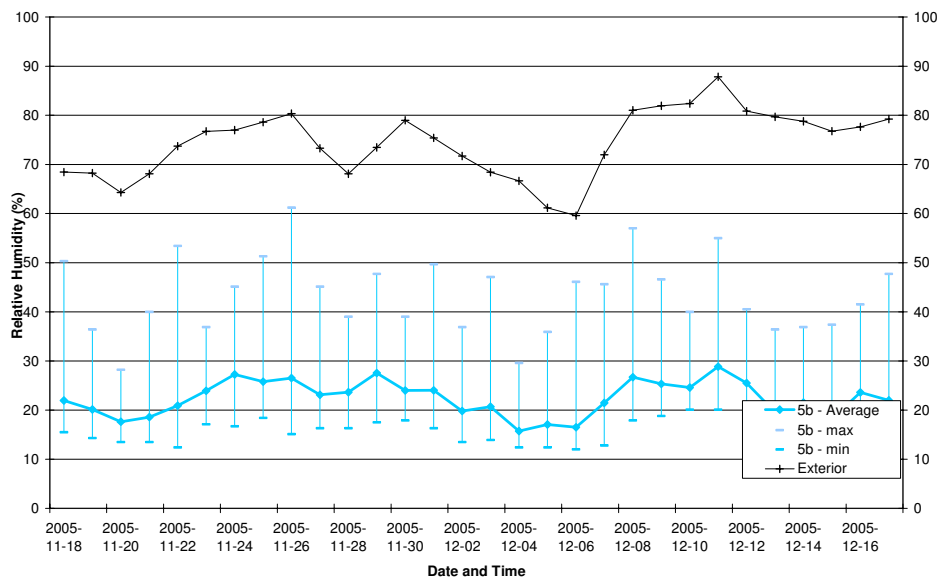
Bathroom Effect- RH extremes

Daily RH peak near 100% in bathrooms

Peaks in kitchens present daily but lower RH

Kitchen(NMT) EGH528 - 5b - Daily Relative Humidity

House 5 - NMT - 3 occupants - 10.9 ACH@50Pa - kitchen sensor

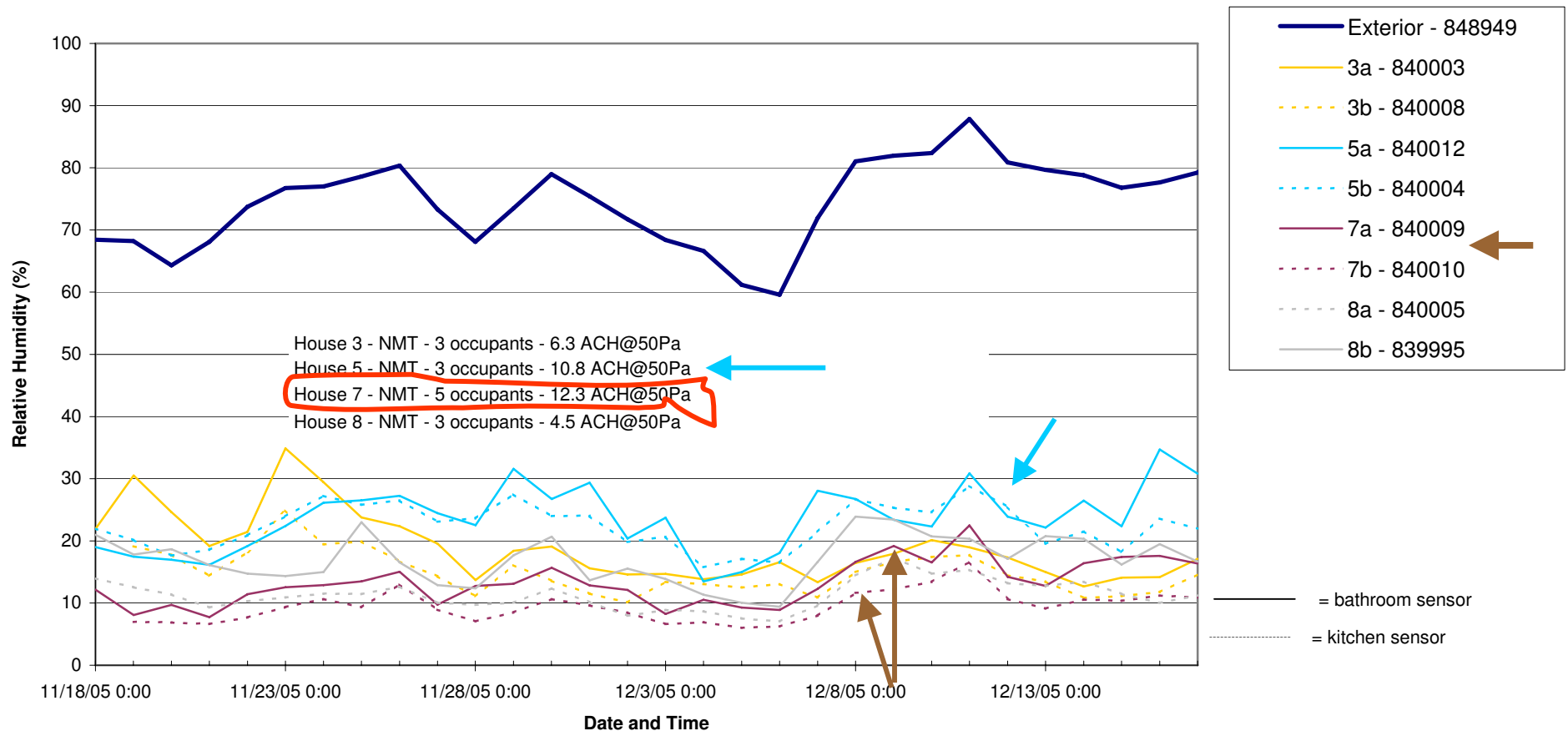


Higher occupancy loads did not translate in higher indoor RH (air exchange –natural and mechanical- is another factor)

Indoor RH versus occupancy load- NMT

INUVIK

Average Daily Relative Humidity - Non Moisture-Troubled Houses



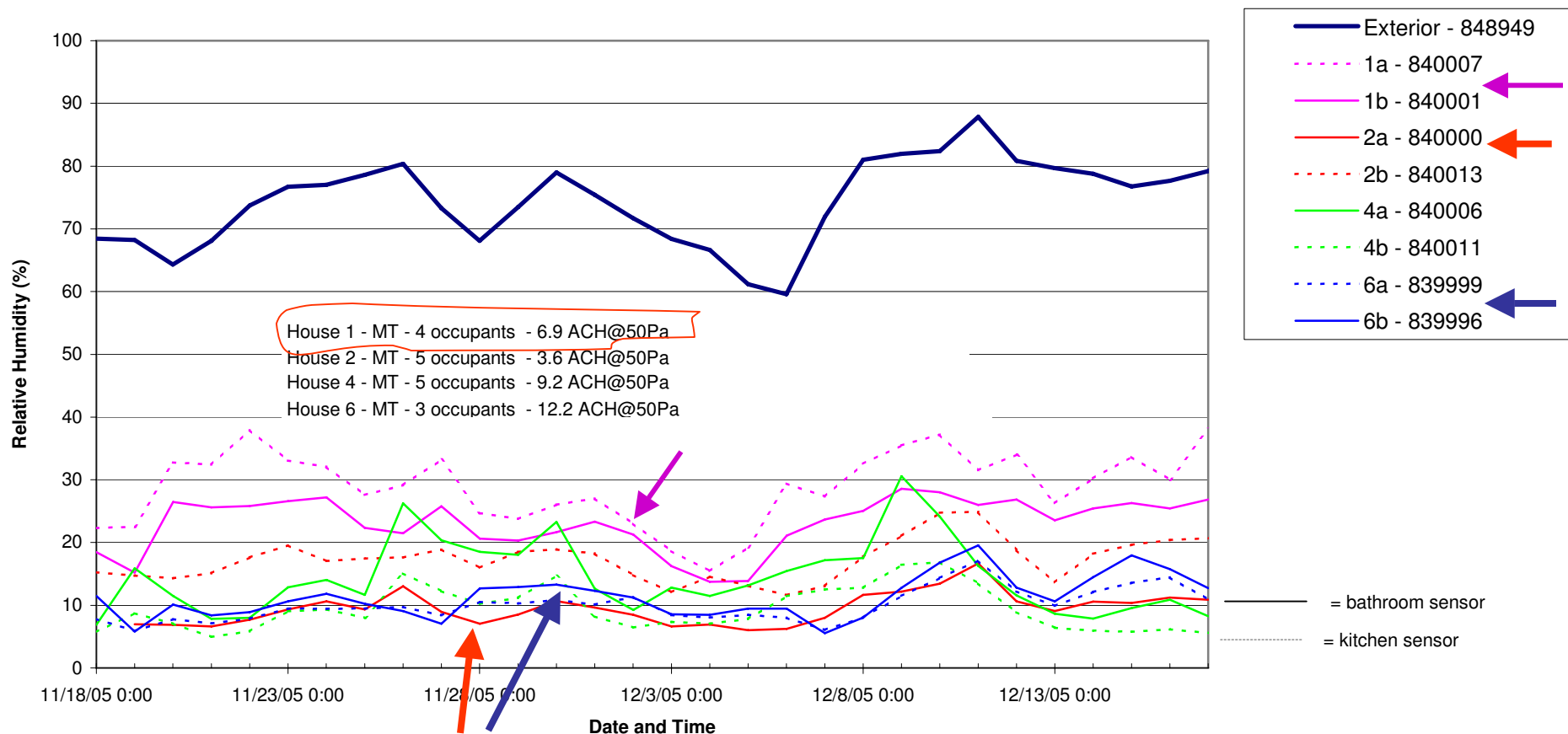
House #1 has highest daily average RH

Houses 2 and 6 have lowest average daily RH with different occupancy and very different air leakage characteristics

Indoor RH versus occupancy load- MT

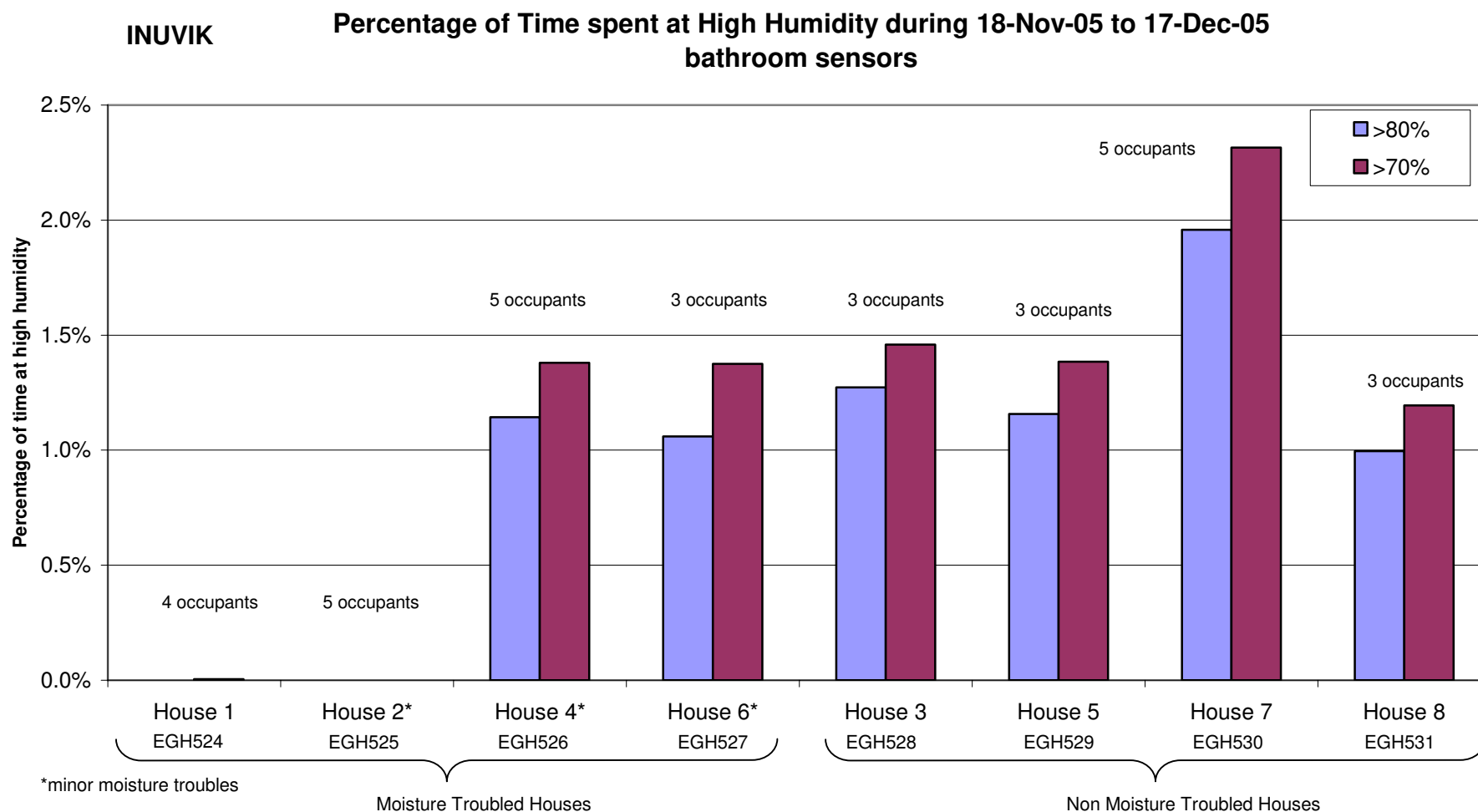
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Average Daily Relative Humidity - Moisture-Troubled Houses



Bathrooms: NMT sample experienced more higher RH events

Time spent at High Humidity- Bathrooms

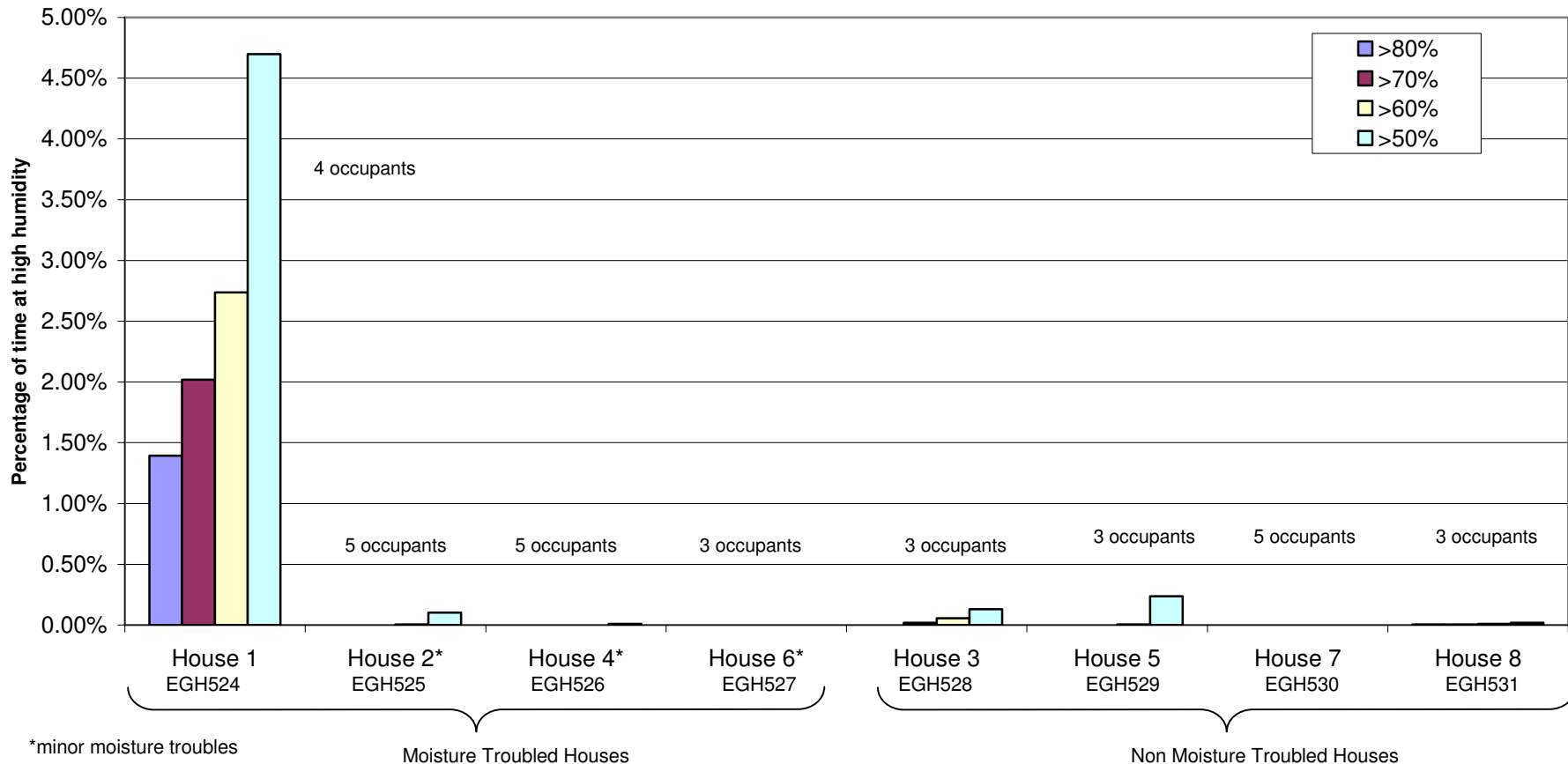


**Kitchens: Both samples experienced
no/few high RH events**

Time spent at High Humidity- Kitchens

INUUVIK

Percentage of Time spent at High Humidity during 18-Nov-05 to 17-Dec-05
kitchen sensors



*****House 1 may have had
its 2 Hobo sensors mixed...**

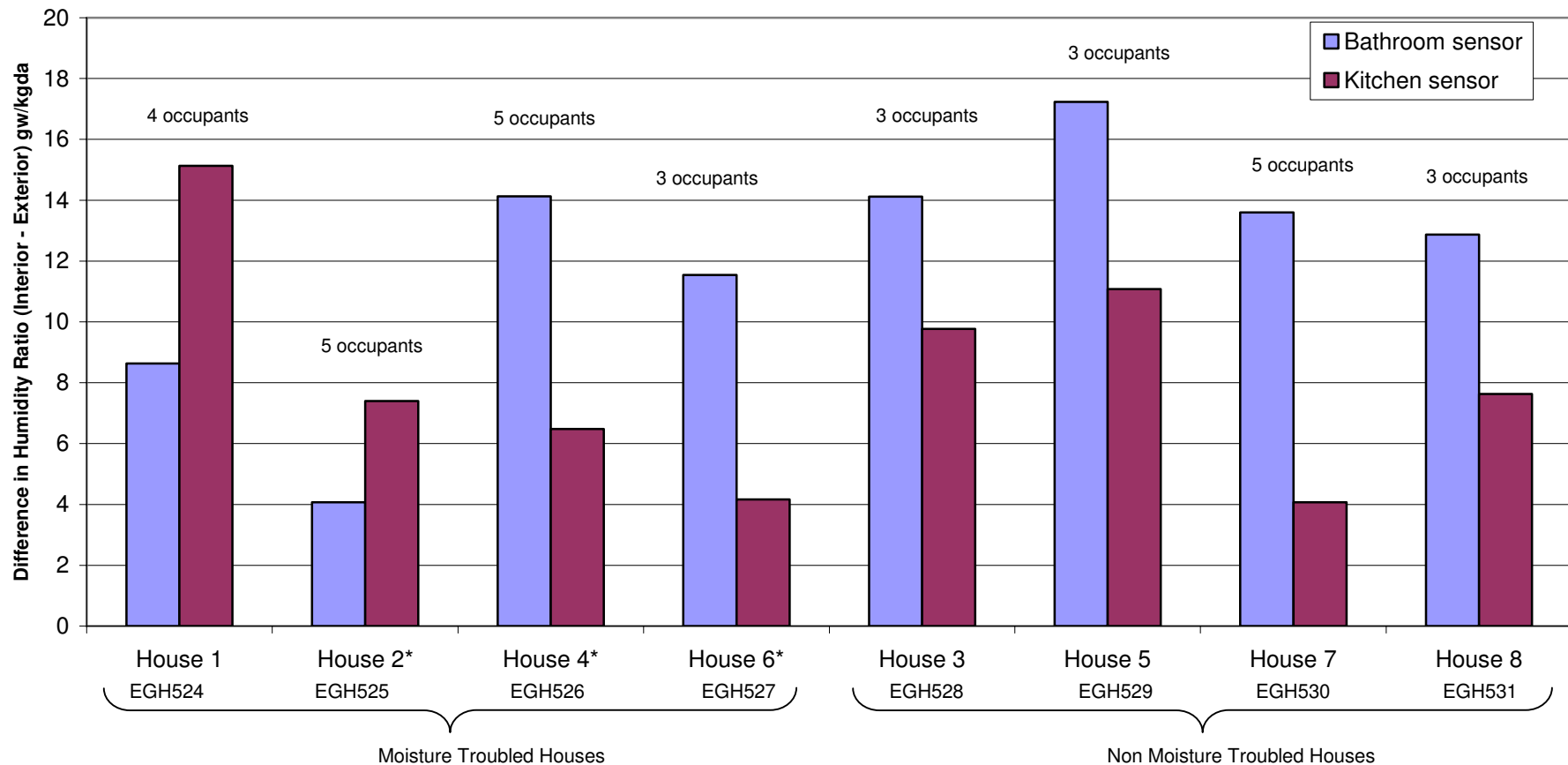
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- Range of indoor moisture loads :
from 4g/kg_{da} to 17 g_w/kg_{da}
- NMT sample experienced higher moisture loading than MT

Difference in Humidity Ratio (Exterior – Interior)

INUVIK

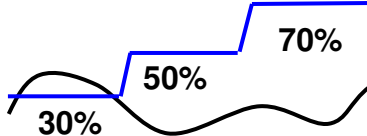
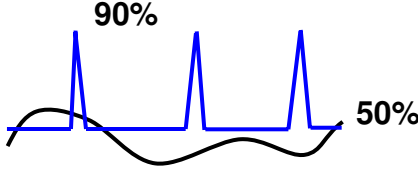
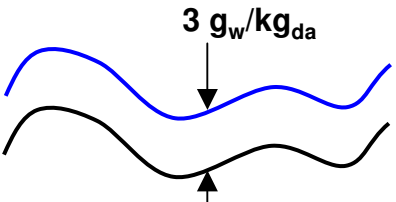
Maximum Difference in Humidity Ratio (Exterior - Interior)
18-Nov-05 to 17-Dec-05



Summary

- Range of indoor moisture loads :
from 4g/kg_{da} to $17\text{ g}_w/\text{kg}_{\text{da}}$
- NMT sample experienced higher moisture loading than MT
- Outdoor conditions: -22°C average (range: -41°C to -4°C)
- Indoor temperature: 24.4°C average (range: 20°C to 26°C)
- Indoor humidity: 16% average (range: 9% to 29%)
- Problems appear related to condensation on windows and melting water damage , and cold air infiltration
- High humidity events in bathrooms present, however, less than 5% of time spent above 50% humidity, and less than 2% of time spent above 80% humidity.
- Kitchen humidity levels rarely surpassed 50%

Input for Experimental Studies

Scenarios	Indoor Conditions Outdoor Conditions	Comments
Constant RH and T		Max. monthly average measured indoors
Ramping RH levels, constant T		3 Levels: low, average, high e.g. 30%, 50%, 70%
Constant combined with short-lived peaks		Max. monthly average and extreme 20 minutes peaks (e.g. 90% RH)
Dynamic offset of moisture over outdoor absolute moisture level		Additional 1-3 grams water/kg of dry air into indoor air over outdoor level